RECEIVED

SEP 03 1998

OSTI

DE-FC21-95MC32260-1

DOE/MC/32260--1

**PTC-6 Vacuum System
WallWaler™
Blastrac® Shot Blast Cleaning System**

**Topical Report
February 1998**

Work Performed Under Contract No.: DE-FC21-95MC32260

For

U.S. Department of Energy
Office of Environmental Management
Office of Technology Development
1000 Independence Avenue
Washington, DC 20585

U.S. Department of Energy
Office of Fossil Energy
Federal Energy Technology Center
P.O. Box 880
Morgantown, West Virginia 26507-0880

MASTER

just

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

By
Operating Engineers National HAZMAT Program
1293 Airport Road
Beaver, West Virginia 25813

Disclaimer

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owed rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

LTC AMERICAS, INC.
PTC-6 SYSTEM (WALL DECONTAMINATION)
HUMAN FACTORS ASSESSMENT

SECTION 1 – SUMMARY

Technology Description

The LTC wall decontamination technology consisted of two pneumatic hand tools: (1) a roto-peen scaler that used star cutters; and (2) a 3-piston hammer with reciprocating bits. The hand tools were used in conjunction with the LTC PTC-6 vacuum system which captured dust and debris as wall decontamination took place.

The PTC-6 is a vacuum system designed to be used with surface decontamination equipment. Dust and debris are captured by a high efficiency particulate air filter (HEPA) vacuum system that deposits the waste directly into an on-board 23-gallon waste drum. The PTC-6 utilizes compressed air to drive the hand-held power tools. The air is delivered to the tools by air hoses which are attached to the control panel. A third compressed air flow directs waste into an on-board 23-gallon waste drum.

Due to the high humidity environment in which the testing demonstration took place, LTC used an air dryer in-line with the system. This is not required for operation but is intended to keep the air lines free of moisture.

Key Results

The safety and health evaluation during the testing demonstration focused on two main areas of exposure: dust and noise. Dust exposure was minimal, but noise exposure was significant. Further testing for each exposure is recommended because of the semi-pen environment where the testing demonstration took place. It is feasible that the dust and noise levels will be higher in an enclosed operating environment of different

construction. Other hazards found were arm-hand vibration, ergonomics, heat stress, tripping hazards, pressure hazards, machine guarding, and lockout/tagout.

SECTION 2 – HEALTH AND SAFETY EVALUATION

General Safety and Health Concerns

Safety and health issues of concern with the LTC wall decontamination technology included tripping hazards, pressure hazards, rotating machinery, lockout/tagout, heat stress, ergonomics, arm-hand vibration, noise, dust, and communication.

Industrial Hygiene Monitoring

During the testing demonstration, sampling was conducted for dust and noise. In addition, the wet-bulb globe temperature was monitored and observational evaluation was conducted for ergonomics and arm-hand vibration.

Ergonomically there is potential for muscle/back stress and/or injury to the shoulders and knees. Arm-hand vibration was not quantitatively measured, but it was readily apparent that there was exposure to arm-hand vibration that could potentially cause health problems such as Raynaud's syndrome.

Heat stress was monitored using the wet-bulb globe measurements and work/rest regimen recommendations were made in accordance with ACGIH recommendations.

Personal air sampling was conducted on the equipment operators. Personal dust sampling showed results both below and above the OSHA permissible exposure limit (PEL) and the ACGIH threshold limit value (TLV) of 10

mg/m³ and 10 mg/m³ respectively for total dust. The higher results may be accounted for by large pieces of concrete debris visible on the filters after the sampling period.

Noise monitoring showed a noise dose of 209.54% which gives an 8-hour time weighted average (TWA) of 95.3 dBA for operator number 1 and a noise dose of 236.96% (TWA 96.2 dBA) for operator number 2.

This exceeds the OSHA action level of 85 dBA and the PEL of 90 dBA. A hearing conservation program will be essential for anyone working with or around this equipment.

Human Factors Interface

The need to utilize different levels of personal protective equipment, such as Level A, B, C, or D will depend on the contaminants associated with the wall being decontaminated. These contaminants should be identified by the site characterization prior to the start of the wall decontamination job.

The level of protection being utilized has the potential to cause several different human factors interface type problems. These may include but not be limited to visibility, manual dexterity, tactile sensation, an increase in heat stress, and an overall increase in physical stress.

SECTION 3 – TECHNOLOGY APPLICABILITY

On observation the technology did not deposit much visible dust into the atmosphere and air monitoring did not evidence an excessive dust level. There was, however, some larger debris on the sampling filters left on the walking surface.

The wall decontamination system will need to be disassembled to be decontaminated. This will not necessarily guarantee that decontamination will be complete. Special care will need to be taken to ensure the equipment is "clean". If this is not possible, it may need to be considered consumable.

SECTION 4 - REGULATORY/POLICY ISSUES

The site safety and health personnel where the LTC wall decontamination technology is being used need to be concerned with safety and health regulations applicable to the issues discussed above. Regulations that will apply may include but not be limited to the following areas: housekeeping, hand and power tools, machine guarding, lockout/tagout, toxic and hazardous substances, noise, respiratory protection, PPE, HAZCOM, HAZWOPER, and arm-hand vibration.

SECTION 5 – OPERATIONAL CONSIDERATIONS AND RECOMMENDATIONS

Recommendations for improved worker safety and health include good housekeeping, ergonomic training and awareness, a clamping system for vacuum hoses, assuring proper vacuum adjustment for adequate air flow, and engineering, administrative, and/or hearing protection be used for compliance with the OSHA noise standard.

WHEELABRATOR BLASTAC® SHOT BLAST CLEANING SYSTEM

HUMAN FACTORS ASSESSMENT - BASELINE

SECTION 1 - SUMMARY

Technology Description

The Wheelabrator Blastac® Model 1-15D coupled with Model 654-DC dust collection system was used during the current testing demonstration. The Blastac® is a surface preparation downblast machine for closed-cycle abrasive cleaning of horizontal surfaces. Surface contaminant and surface removal are accomplished by the impact of metallic abrasive thrown by controlled centrifugal force from a power driven bladed wheel. The thrown abrasive impacts the surface and rebounds upwardly into a rebound chamber, which then directs the abrasive into an airwash dust extractor. The dust extractor removes dust, scale and other contaminants from the abrasive. The shot is then delivered by gravity to the storage hopper for reuse by the blast wheel. The Blastac® is self-propelled by a variable speed electric drive system. The rate of speed the Blastac® is traveling determines the depth of surface material removed.

Key Results

The safety and health evaluation during the testing demonstration focused on two main areas of exposure: dust and noise. Dust exposure was minimal, but noise exposure was potentially significant. Further testing for each of these exposures is recommended, because the outdoor environment where the testing demonstration took place may cause the results to be inapplicable to enclosed work areas. It is feasible that the dust and noise levels will be higher in an enclosed operating environment. Other safety and health issues found were ergonomics, heat stress, tripping/slipping hazards, electrical hazards and lockout/tagout.

SECTION 2 - HEALTH AND SAFETY EVALUATION

General Safety and Health Concerns

Safety and health issues of concern with the Blastac® shot blast technology included tripping/slipping hazards, electrical hazards, rotating machinery, lockout/tagout, heat stress, ergonomics, noise, dust and communication.

Industrial Hygiene Monitoring

During the testing demonstration, sampling was conducted for dust and noise. The wet-bulb globe temperature was also monitored. Observational evaluation was conducted for ergonomics.

Ergonomically there is potential for muscle/back stress and/or injury to the knees. Of particular concern was the need to manually remove the dust bin and dump the dust from it. This increases back stress and causes an increase in exposure to the contaminant.

Heat stress was monitored using wet-bulb globe measurements and work/rest regimen recommendations were made in accordance with ACGIH recommendations.

Personal air sampling was conducted on the equipment operator. Personal dust sampling values were below allowable levels. Noise monitoring resulted in a dose of 29.73% and 23.78% or an 8-hour TWA of 81.2 dBA and an 8-hour TWA of 79.6 dBA. This does not exceed the OSHA action level of 85 dBA and the permissible exposure of 90 dBA for the amount of time sampled. An overexposure may occur for a full 8-hour work shift. A hearing conservation program

may be necessary for anyone working with or around this equipment.

Human Factors Interface

The technology was evaluated for operator interface with Anti-C PPE including a full face air-purifying respirator. Operators wearing the PPE experienced some visibility problems due to the full face respirator, and some loss of tactile sensation and dexterity during maintenance activities. In addition, there was an increase in heat stress associated with the protective ensemble.

SECTION 3 - TECHNOLOGY APPLICABILITY

On observation, the technology did not deposit much visible dust into the atmosphere. Air monitoring did not evidence an excessive dust level. There was some larger debris left on the surface at the sides of the shot blast head.

The shot blaster will need to be disassembled to be decontaminated. This will not necessarily guarantee that decontamination for alpha radiation will be complete. It will be difficult to survey for alpha contamination due to all of the small spaces in the equipment that are hard to reach with a probe.

SECTION 4 - REGULATORY/POLICY ISSUES

The site safety and health personnel where the centrifugal shot blaster technology is being used need to be concerned with safety and health regulations applicable to the issues discussed above. Regulations that will apply may include but not be limited

to the following areas: housekeeping, electrical, machine guarding, lockout/tagout, ionizing radiation, toxic and hazardous substances, noise, respiratory protection, PPE, HAZCOM and HAZWOPER.

SECTION 5 - OPERATIONAL CONSIDERATIONS & RECOMMENDATIONS

Recommendations for improved worker safety and health include good housekeeping, ergonomic training and awareness, proper gloves for handling the hot plate used for control cage adjustment, use of a lockout/tagout program, building redundancies into the control panels, a mechanism (besides the hands) to remove shot from the magnet, assuring proper capture velocity for adequate air flow, using a HEPA vacuum system, and engineering, administrative, and/or hearing protection be used for compliance with the OSHA noise standard.

Due to the windy outdoor testing conditions, it is recommended that the noise and dust monitoring be conducted while the technology is in use in an enclosed environment.

Research supported by the U.S. Department of Energy's Federal Energy Technology Center, under cooperative agreement DE-FC21-95MC32260 with the Operating Engineers National HAZMAT Program, 250 Airport Circle, Beaver, WV 25813, phone 304-253-8674, fax 304-253-7758. This report was prepared with the support of the US DOE; however, any opinions, findings, conclusions, or recommendations expressed herein are those of the author(s) and do not necessarily reflect the views of the DOE.

PENTEK, INC.

WALLWALKER™

HUMAN FACTORS ASSESSMENT

SECTION 1 - SUMMARY

Technology Description

The Pentek WallWalker™ consists of a remotely operated, computer controlled positioning system interfaced with a scabber for the removal of coatings and concrete from vertical surfaces. The integrated WallWalker™ remote positioning/decontamination system consists of a motion control system, scabber head interface, and a HEPA vacuum system.

The motion control system precisely controls the position, velocity, and acceleration of the scabber head over the entire vertical plane.

The operator interface consists of a touch control screen for entering the physical/geometric setup parameters and motion profiles.

The WallWalker™ scabber head utilizes a "low-friction" static seal by maintaining a vacuum flow for dust and contamination control, while maximizing the vacuum pressure between the scabber and the wall.

Vacuum flow is provided via a VAC-PAC® which has two stage positive filtration sufficient to support safe and efficient vacuuming of materials. First stage roughing filter efficiency is 95% at 1 micron, with second stage HEPA efficiency of 99.97% at 0.3 microns.

Key Results

The safety and health evaluation during the testing demonstration focused on two main areas of exposure: dust and noise. Dust exposure was minimal, but noise exposure was potentially significant. Several of the

samples taken were in excess of the OSHA PEL and ACGIH TLV but this may be accounted for by the visible grit and large pieces of concrete on the sampling filter. Other hazards found were ergonomics, heat stress, tripping hazards, electrical hazards, machine guarding, and lockout/tagout.

SECTION 2 – HEALTH AND SAFETY EVALUATION

General Health and Safety Concerns

Safety and health issues of concern with the WallWalker™ included tripping hazards, rotating machinery, lockout/tagout, heat stress, ergonomics, electrical hazards, noise, dust, and lockout/tagout.

Industrial Hygiene Monitoring

During the testing demonstration, sampling was conducted for dust and noise. In addition, the wet-bulb globe temperature was monitored and observational evaluation was conducted for ergonomics.

Ergonomically there is potential for muscle/back, shoulder and arm stress and/or injury due to the pushing, pulling, lifting, and bending required to set up and move the WallWalker™.

Heat stress was monitored using wet-bulb globe measurements and work/rest regimen recommendations were made in accordance with ACGIH recommendations.

Area air sampling was conducted in the area of the operator's station and at the scabbling head. All area dust samples collected at the operator station showed results below the

OSHA permissible exposure limit (PEL) and the ACGIH threshold limit value (TLV) of 15 mg/m³ and 10 mg/m³, respectively for total dust. All area dust samples collected at the head of the scabbler showed results in excess of the PEL and TLV. This may be accounted for by the visible grit and larger pieces of concrete on the sampling filter. Dust however, needs to be considered a potential exposure hazard and a monitoring plan will need to be developed where the WallWalker™ is being used.

Area noise monitoring in the area of the operator station and the ancillary equipment showed noise doses both below and in excess of the OSHA action level of 85 dBA and the PEL of 90 dBA. Exposure will be influenced by the amount of time the worker spends at the operator station, in the scabbling area, and around the ancillary equipment. A hearing conservation program may be necessary where the WallWalker™ is being used. Job specific noise monitoring will need to be conducted to determine the exposure levels.

Human Factors Interface

The need to utilize different levels of personal protective equipment, such as Level A, B, C, or D will depend on the contaminants associated with the wall being decontaminated. These contaminants should be identified by the site characterization prior the start of the wall decontamination job.

The level of protection being utilized has the potential to cause several different human factors interface type problems. These may include but not be limited to visibility, manual dexterity, tactile sensation, an increase in heat stress, and an overall increase in physical stress.

SECTION 3 – TECHNOLOGY APPLICABILITY

The technology produced some visible dust when the seal with the wall was disrupted during operation. All dust samples were below the OSHA PEL and the ACGIH TLV or contained grit and large pieces of concrete. Noise monitoring indicated that workers are likely to be overexposed in accordance with the OSHA PEL and the ACGIH TLV after an 8-hour work shift.

The WallWalker™ will need to be disassembled to be decontaminated. This will not necessarily guarantee that the equipment will be "clean". Parts of the system may need to be considered consumables.

SECTION 4 – REGULATORY/POLICY ISSUES

The site safety and health personnel where the WallWalker™ is being used need to be concerned with safety and health regulations applicable to the issues discussed above. Regulations that will apply may include but not be limited to the following areas: housekeeping, machine guarding, lockout/tagout, toxic and hazardous substances, noise, respiratory protection, electrical hazards, scaffolding, ladder safety, PPE, HAZCOM, and HAZWOPER.

SECTION 5 – OPERATIONAL CONSIDERATIONS & RECOMMENDATIONS

Recommendations for improved worker safety and health include good housekeeping, ergonomic training and awareness, requiring the operator to stay at the control station at all times, labeling the computer screen "touch screen", labeling pinch points, and an interlock to keep fingers/hands from being crushed in pinch points.

PEGASUS INTERNATIONAL, INC.
COATING REMOVAL SYSTEM (PCRS)
(WALL/CEILING)
HUMAN FACTORS ASSESSMENT

SECTION 1 - SUMMARY

Technology Description

The PCRS is a chemical paste that is applied to the surface using a brush, roller, or airless sprayer. The type of PCRS used depends on the type and thickness of the coating, the age of the coating, and the type of substrate material. A laminated backed material is placed on top of the chemical paste to slow down the drying process and to provide a mechanism to strip-off the material. In order to determine the type of PCRS, the required thickness of the paste, and the dwell time, a test area of approximately one square foot is used. Based on the performance of the chemical over this one square foot area, the operational parameters can be determined. Dwell time can range from several hours to 24 hours.

Key Results

The safety and health hazard evaluation during the testing demonstration focused on two main areas: exposure to organic chemicals and ergonomics. Air sampling with a photo ionization detector (PID) showed low exposure values but there is concern for skin exposures. Ergonomic stressors were potentially significant. Further testing for the individual ingredients of the organic based solvent is recommended. In addition, it is recommended that sampling be conducted in an enclosed environment because the outdoor environment where part of the testing demonstration took place may cause the results to be inapplicable to enclosed operating environments, where it is feasible that the exposure levels would be greater. Other safety and health issues found were heat stress, slipping/fall hazards, working from heights, and environmental concerns from accidentally

spreading the chemical to areas outside the exclusion zone.

**SECTION 2 - HEALTH AND SAFETY
EVALUATION**

General Safety and Health Concerns

Safety and health issues of concern with the PCRS included housekeeping, personal protective equipment compatibility with the chemical, ergonomics, heat stress, slipping hazards, and exposure to the chemical.

Industrial Hygiene Monitoring

During the testing demonstration with the PCRS, sampling was conducted for organic vapors. In addition, the wet-bulb globe temperature was monitored and observational evaluation was conducted for ergonomics.

Ergonomically there is potential for muscle/back, shoulder, neck, leg, and knee stress and/or injury due to the bending, lifting, kneeling, and stooping required to apply and remove the PCRS.

Heat stress was monitored using wet-bulb globe measurements and work/rest regimen recommendations were made in accordance with ACGIH recommendations.

Organic vapor monitoring was conducted during application and removal. Monitoring was conducted using a PID (photo ionization detector). The PID is a real-time monitor that measures organic vapors in parts per million (ppm). The PID does not identify the specific organic vapor but identifies the presence of any organic vapor.

The organic vapor readings during application and removal ranged from 0.0 to 5.0 ppm. Since it cannot be determined if these levels present the potential for overexposure, sampling for the individual ingredients in the PCRS-5/7 needs to be conducted. These readings do indicate that organic vapors are present. Even at low levels, the organic vapor odor could be detected, especially when down wind of the work area. These low levels have the potential to cause headache, skin irritation, and respiratory tract irritation. Therefore, workers may need to utilize PPE when applying and removing the PCRS regardless of the ppm levels recorded.

Environmental conditions such as air temperature, radiant heat load, and ventilation in the area can affect how rapidly the organic solvent mixture vaporizes and therefore, the exposure level at a given time. The exposure level (vapor build-up) will also be affected by the size of the area where it is being used. A monitoring plan will need to be developed for the specific site and job where the chemical is being used.

Human Factors Interface

The MSDS for PCRS-5/7 recommends the following PPE be used when applying or removing it: chemical goggles, butyl rubber gloves, impervious apron, and boots. It states that respiratory protection is not normally needed but for spray applications or where exposures may be excessive, a NIOSH approved organic vapor respirator may be used.

Depending on the application and removal methods used, a greater level of protection may be required. This may include a chemically impervious suit instead of only an apron and a full face air purifying respirator. This greater level of protection has the potential to cause a decrease in visibility, mobility, and tactile sensation for the workers as well as an increase

in heat stress. Additionally, because of the extremely slippery walking surface condition caused by the chemical, boots with special anti-slip soles need to be used.

SECTION 3 - TECHNOLOGY APPLICABILITY

After the coating has been removed from the surface by the chemical, it will need to be assured that the surface is "clean" of both PCRS residue and whatever contaminant was originally present on the surface.

Consideration will also need to be given to the wastes that are generated. Wastes may include different combinations: the PCRS itself and the PCRS combined with the surface coating being removed and its contaminants.

SECTION 4 - REGULATORY/POLICY ISSUES

The site safety and health personnel where the PCRS technology is being used need to be concerned with safety and health regulations applicable to the issues discussed above. Regulations that will apply may include but not be limited to the following areas: housekeeping, ergonomics training and awareness, scaffolding, ladders, toxic and hazardous substances, respiratory protection, PPE, HAZCOM, and HAZWOPER.

SECTION 5 - OPERATIONAL CONSIDERATIONS & RECOMMENDATIONS

Recommendations for improved worker safety and health include good housekeeping, work practices that lower the risk of exposure to the chemical, ergonomic training and awareness, assuring the PPE is compatible with the chemical being used, assuring hoses and other equipment are compatible with the chemical being used, scaffolding safety, and the use of special non-slip soles on boots.

**PEGASUS INTERNATIONAL, INC.
COATING REMOVAL SYSTEM (PCRS)
(CONCRETE FLOOR)
HUMAN FACTORS ASSESSMENT**

SECTION 1 - SUMMARY

Technology Description

The PCRS is a chemical paste that is applied to the surface using a brush, roller, or airless sprayer. The type of PCRS used depends on the type and thickness of the coating, the age of the coating, and the type of substrate material. A laminated backed material is placed on top of the chemical paste to slow down the drying process and to provide a mechanism to strip-off the material. In order to determine the type of PCRS, the required thickness of the paste, and the dwell time, a test area of approximately one square foot is used. Based on the performance of the chemical over this one square foot area, the operational parameters can be determined. Dwell time can range from several hours to 24 hours.

Key Results

The safety and health hazard evaluation during the testing demonstration focused on two main areas: exposure to the organic chemicals and ergonomics. Air sampling with a photo ionization detector (PID) showed low exposure values but there is concern for skin exposures. Further testing for the individual ingredients of the organic based solvent is recommended. In addition, it is recommended that sampling be conducted in an enclosed environment because the outdoor environment where the testing demonstration took place may cause the results to be inapplicable to enclosed operating environments, where it is feasible that the exposure levels would be greater. Ergonomic stressors were potentially significant. Other safety and health issues found were heat stress, slipping/fall hazards, and environmental concerns from accidentally spreading the

chemical to areas outside the exclusion zone.

**SECTION 2 - HEALTH AND SAFETY
EVALUATION**

General Safety and Health Concerns

Safety and health issues of concern with the PCRS included housekeeping, personal protective equipment compatibility with the chemical, ergonomics, heat stress, slipping hazards, and exposure to the chemical.

Industrial Hygiene Monitoring

During the testing demonstration with the PCRS, sampling was conducted for organic vapors. In addition, the wet-bulb globe temperature was monitored and observational evaluation was conducted for ergonomics.

Ergonomically there is potential for muscle/back, leg, knee, and ankle stress and/or injury due to bending, lifting, kneeling, and stooping required to apply and remove the PCRS.

Heat stress was monitored using wet-bulb globe measurements and work/rest regimen recommendations were made in accordance with ACGIH recommendations.

The PCRS applied to the concrete slab for coating removal was the PCRS-5/7, the organic solvent mixture. Dust was not a concern during the application and removal of the PCRS since it was a wet process. Organic vapor monitoring was conducted during application and removal. Monitoring was conducted using an MSA Passport PID. The Passport is a real-time monitor that measures organic vapors in parts per million (ppm). The PID does not identify the specific organic vapor but identifies the

presence of any organic vapor. The organic vapor readings during application and removal ranged from 0.0 to 6.0 ppm. Since it cannot be determined if these levels present the potential for overexposure, sampling for the individual ingredients in the PCRS-5/7 needs to be conducted. It does however indicate that organic vapors are present. Even at low levels, the organic vapor odor could be detected, especially when down wind of the concrete pad. These low levels have the potential to cause headache, skin irritation, and respiratory tract irritation. Therefore, workers may need to utilize appropriate PPE when applying and removing the PCRS regardless of the ppm levels recorded.

Environmental conditions such as air temperature, radiant heat load, and ventilation in the area can affect how rapidly the organic solvent mixture vaporizes and therefore, the exposure level at a given time. The exposure level (vapor build-up) will also be affected by the size of the area where it is being used. The PCRS was applied and removed in an open outdoor environment during the testing demonstration, therefore, there is the potential for the organic vapor levels to be significantly higher in an enclosed environment. A monitoring plan will need to be developed for the specific site and job where the chemical is being used.

Human Factors Interface

The MSDS for PCRS-5/7 recommends the following PPE be used when applying or removing it: chemical goggles, butyl rubber gloves, impervious apron, and boots. It states that respiratory protection is not normally needed but for spray applications or where exposures may be excessive, a NIOSH approved organic vapor respirator may be used.

Depending on the application and removal methods used, a greater level of protection may

be required. This may include a chemically impervious suit instead of only an apron and a full face air purifying respirator. This has the potential to cause a decrease in visibility, mobility, and tactile sensation for the workers as well as an increase in heat stress. Additionally, because of the extremely slippery surface condition, boots with special anti-slip soles need to be used.

SECTION 3 - TECHNOLOGY APPLICABILITY

After the coating has been removed from the surface by the chemical, it will need to be assured that the surface is "clean" of both PCRS residue and whatever contaminant was originally present on the surface.

Consideration will also need to be given to the wastes that are generated. Wastes may include different combinations: the PCRS itself and the PCRS combined with the surface coating being removed and its contaminants.

SECTION 4 - REGULATORY/POLICY ISSUES

The site safety and health personnel where the PCRS technology is being used need to be concerned with safety and health regulations applicable to the issues discussed above. Regulations that will apply may include but not be limited to the following areas: housekeeping, toxic and hazardous substances, respiratory protection, PPE, HAZCOM, and HAZWOPER.

SECTION 5 - OPERATIONAL CONSIDERATIONS & RECOMMENDATIONS

Recommendations for improved worker safety and health include good housekeeping, ergonomic training and awareness, assuring the PPE is compatible with the chemical being used, and use of special non-slip boots.

PEGASUS INTERNATIONAL, INC.
COATING REMOVAL SYSTEM (PCRS)
(METAL)
HUMAN FACTORS ASSESSMENT

SECTION 1 - SUMMARY

Technology Description

The PCRS is a chemical paste that is applied to the surface using a brush, roller, or airless sprayer. The type of PCRS used depends on the type and thickness of the coating, the age of the coating, and the type of substrate material. A laminated backed material is placed on top of the chemical paste to slow down the drying process and to provide a mechanism to strip-off the material. In order to determine the type of PCRS, the required thickness of the paste, and the dwell time, a test area of approximately one square foot is used. Based on the performance of the chemical over this one square foot area, the operational parameters can be determined. Dwell time can range from several hours to 24 hours.

Key Results

The safety and health hazard evaluation during the testing demonstration focused on two main areas: exposure to organic chemicals and ergonomics. Air sampling with a photo ionization detector (PID) showed low exposure values but there is concern for skin exposures. Further testing for the individual ingredients of the organic based solvent is recommended. In addition, it is recommended that sampling be conducted in an enclosed environment because the outdoor environment where part of the testing demonstration took place may cause the results to be inapplicable to enclosed operating environments, where it is feasible that the exposure levels would be greater. Ergonomic stressors were potentially significant. Other safety and health issues found were heat stress, slipping/fall hazards, working from heights, and environmental concerns from accidentally

spreading the chemical to areas outside the exclusion zone.

**SECTION 2 - HEALTH AND SAFETY
EVALUATION**

General Safety and Health Concerns

Safety and health issues of concern with the PCRS included housekeeping, personal protective equipment compatibility with the chemical, ergonomics, heat stress, slipping hazards, and exposure to the chemical.

Industrial Hygiene Monitoring

During the testing demonstration with the PCRS, sampling was conducted for organic vapors. In addition, the wet-bulb globe temperature was monitored and observational evaluation was conducted for ergonomics.

Ergonomically there is potential for muscle/back, leg, knee, and ankle stress and/or injury due to the bending, lifting, kneeling, and stooping required to apply and remove the PCRS.

Heat stress was monitored using wet-bulb globe measurements and work/rest regimen recommendations were made in accordance with ACGIH recommendations.

The PCRS applied to the metal for coating removal was the PCRS-5/7, the organic solvent mixture. Dust is not a concern during the application and removal of the PCRS since it is a wet process. Organic vapor monitoring was conducted during application and removal. Monitoring was conducted using a photo ionization detector (PID). The PID is a real-time monitor that measures organic vapors in parts per million (ppm). The PID does not identify the

specific organic vapor but identifies the presence of any organic vapor.

The organic vapor readings during application and removal ranged from 0.0 to 15.0 ppm, the higher readings being recorded in the enclosed work environment. Since it cannot be determined if these levels present the potential of overexposure, sampling for the individual ingredients in the PCRS-5/7 needs to be conducted. It does however indicate that organic vapors are present. Even at low levels, the organic vapor odor could be detected, especially when down wind of the work area. These low levels have the potential to cause headache, skin irritation, and respiratory tract irritation. Therefore, workers may need to utilize appropriate PPE when applying and removing the PCRS, regardless of the ppm levels recorded.

Environmental conditions such as air temperature, radiant heat load, and ventilation in the area can affect how rapidly the organic solvent mixture vaporizes and therefore, the exposure level at a given time. The exposure level (vapor build-up) will also be affected by the size of the area where it is being used. A monitoring plan will need to be developed for the specific site and job where the chemical is being used.

Human Factors Interface

The MSDS for PCRS-5/7 recommends the following PPE be used when applying or removing it: chemical goggles, butyl rubber gloves, impervious apron, and boots. It states that respiratory protection is not normally needed but for spray applications or where exposures may be excessive, a NIOSH approved organic vapor respirator may be used.

Depending on the application and removal methods used, a greater level of PPE may be

required. This may include a chemically impervious suit instead of only an apron and a full face air purifying respirator. This has the potential to cause a decrease in visibility, mobility, and tactile sensation for the workers as well as an increase in heat stress. Additionally, because of the extremely slippery work surface condition, boots with special anti-slip soles need to be used.

SECTION 3 - TECHNOLOGY APPLICABILITY

After the coating has been removed from the surface by the chemical, it will need to be assured that the surface is "clean" of both PCRS residue and whatever contaminant was originally present on the surface.

Consideration will also need to be given to the wastes that are generated. Wastes may include different combinations: the PCRS itself and the PCRS combined with the surface coating being removed and its contaminants.

SECTION 4 - REGULATORY/POLICY ISSUES

The site safety and health personnel where the PCRS technology is being used need to be concerned with safety and health regulations applicable to the issues discussed above. Regulations that will apply may include but not be limited to the following areas: housekeeping, toxic and hazardous substances, respiratory protection, PPE, HAZCOM and HAZWOPER.

SECTION 5 - OPERATIONAL CONSIDERATIONS & RECOMMENDATIONS

Recommendations for improved worker safety and health include good housekeeping, ergonomic training and awareness, assuring the PPE is compatible with the chemical being used, and the use of special non-slip boots.

LTC AMERICAS, INC.
PTC-6 VACUUM SYSTEM
TABLE OF CONTENTS

ACQUISITION & ASSISTANCE

1998 MAR 25 P 2:31

USDOE-FETC

ACKNOWLEDGEMENTS.....	iii
EXECUTIVE SUMMARY	iv
SECTION 1 - SUMMARY	1
Technology Description	1
Key Results	1
SECTION 2 - SYSTEM OPERATION.....	1
SECTION 3 - HEALTH AND SAFETY EVALUATION	2
General Health and Safety Concerns	2
Core Issues	2
Best Management Practices.....	3
Industrial Hygiene Monitoring	4
Human Factors Interface	6
Technology Applicability	7
SECTION 4 - JOB SAFETY ANALYSIS (JSA)	8
SECTION 5 - FAILURE MODE AND EFFECTS ANALYSIS (FMEA)	12
SECTION 6 - TECHNOLOGY SAFETY DATA SHEET (TSDS)	13
SECTION 7 - EMERGENCY RESPONSE/PREPAREDNESS	23
SECTION 8 - REGULATORY POLICY ISSUES.....	23
Core Requirements	23
Technology Specific Requirements	24
Best Management Practices.....	25
Core Training Requirements.....	26
Technology Specific Training.....	26
Special Training.....	26
Best Management Practice Training.....	26

TABLE OF CONTENTS (CONTINUED)

SECTION 9 - OPERATIONAL CONSIDERATIONS AND RECOMMENDATIONS	27
APPENDIX A - REFERENCES	30
APPENDIX B - INDUSTRIAL HYGIENE DATA.....	31
APPENDIX C - ACRONYMS.....	34

ACKNOWLEDGEMENTS

The human factors assessment of LTC Americas, Inc., was conducted under support of the U. S. Department of Energy's Federal Energy Technology Center, under cooperative agreement DE-FC21-95MC32260 with the Operating Engineers National Hazmat Program. The Operating Engineers National Hazmat Program would like to thank the following people for their participation on the "research action team" and the professional expertise they provided for this assessment:

Barbara McCabe
Ralph Pascarella
Pat Bell

Operating Engineers National Hazmat Program
Operating Engineers Local Union 30
Operating Engineers National Hazmat Program

EXECUTIVE SUMMARY

The LTC wall decontamination technology consisted of two pneumatic hand-held tools: (1) a roto-peen scaler that used star cutters and (2) a 3-piston hammer with reciprocating bits. The hand-held tools were used in conjunction with the LTC PTC-6 vacuum system which captured dust and debris as the wall decontamination took place.

The PTC-6 is a vacuum system designed to be used with surface decontamination equipment. Dust and debris are captured by a high efficiency particulate air (HEPA) filter vacuum system that deposits the waste directly into an on-board 23-gallon waste drum. The PTC-6 utilizes compressed air delivered, from a source, via a hose connected to the air inlet, to drive the hand-held power tools. The air is delivered to the tools by air hoses which are attached to the control panel. The control panel regulates the air pressure delivered to the tool. A separate compressed air flow powers the vacuum generator. The vacuum hoses connect the power tools to the dust chamber, returning paint chips and dust from the surface. A third compressed air flow is used to clean filters by pulsing air through a pipe with slots. The blasts of air shake dust and debris from the filter fabric.

During the assessment sampling was conducted for dust and noise and general observational techniques were conducted for ergonomics. General observational techniques for ergonomics showed the potential for some ergonomic problems during wall surface coating removal using the LTC wall decontamination technology. There is potential for muscle/back stress and/or injuries due to bending, twisting, and lifting associated with setup, operation, maintenance, and decontamination. Additionally, there is potential for back muscle sprain/strain from the static postures that had to be assumed to place enough force on the tool to keep it in contact with the wall surface. In addition, arm/hand vibration was noted and needs to be taken into consideration since this type of exposure has the potential to cause injury, such as that associated with Raynaud's Syndrome.

Personal air sampling was conducted on the equipment operators during the wall decontamination demonstration. Personal dust sampling values of 28.60 mg/m³ and 0.00 mg/m³ were obtained for operator Number 1 and 30.82 mg/m³ and 0.00 mg/m³ for operator Number 2. One value for each operator exceeds the Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) and the American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV) of 15 mg/m³ and 10 mg/m³ respectively for total dust. This may be accounted for by the large pieces of concrete debris that was visible on the sampling filters on the day when the dust results were elevated. This occurred on the first day of the wall decontamination demonstration. The next day, the sampling results showed no dust accumulation and there was no visible debris on the filters. This may, in part, be attributed to the operators adjusting to using the hand-held tools on the wall surface. This

illustrates the importance of worker training to include instructing the worker on developing and using work habits that keep him/her from exposure to hazards.

Personal noise monitoring showed noise levels of 209.54% which would give an 8-hour time weighted average (TWA) of 95.3 dBA for operator Number 1 and 236.96% (TWA of 96.2 dBA).

The OSHA allowable PEL for noise is a 100% dose or an 8-hour TWA of 90 dBA. The operators were over exposed during the sampling periods. At these exposure levels, personnel would be required to be included in a hearing conservation program. Feasible engineering controls, administrative controls, and personal protective equipment need to be used. The noise levels produced by the wall decontamination system may require that engineering and administrative controls, as well as hearing protection devices, all be simultaneously employed to control the noise level.

Recommendations for improved worker safety and health during use of the PTC-6 vacuum system with hand-held tools include: 1. keeping all hoses and lines as orderly as possible in compliance with good housekeeping requirements; 2. ergonomic training to include techniques in lifting, bending, stooping, twisting, etc.; 3. use of a clamping system to hold hoses to the vacuum system; 4. a safety line on the air line connections; 5. use of a mechanical lifting system for waste drum removal; and 6. the use of ergonomically designed tools.

LTC Americas, Inc.

PTC-6 Vacuum System (Wall Decontamination)

Human Factors Evaluation

SECTION 1 - SUMMARY

TECHNOLOGY DESCRIPTION

The LTC wall decontamination technology was tested and is being evaluated at Florida International University (FIU) as a baseline technology. In conjunction with FIU's evaluation of efficiency and cost, this report covers the hazard analysis and safety evaluation. The LTC PTC-6 is a commercially available technology and has been used for various projects at locations throughout the country.

The LTC wall decontamination technology consisted of two different pneumatic hand-held tools: (1) a roto-peen scaler that used star cutters; and (2) a 3-piston hammer with reciprocating bits. The hand-held tools were used in conjunction with the LTC PTC-6 vacuum system which captured dust and debris as the wall decontamination took place.

KEY RESULTS

The safety and health evaluation during the testing demonstration focused on two main areas of exposure: dust and noise. Dust exposure was minimal but noise exposure was significant. Further testing for each exposure is recommended because of the semi-open environment where the testing demonstration took place. It is feasible that the dust and noise levels will be higher in a fully enclosed operating environment. It appears that dust and noise surveys will be required in all operational settings where the LTC wall decontamination technology is used. Other areas of concern were arm-hand vibration, ergonomics, heat stress, tripping hazards, pressure line hazards, machine guarding, and lockout/tagout.

SECTION 2 - SYSTEM OPERATION

The LTC wall decontamination technology consisted of two pneumatic hand-held tools: (1) a roto-peen scaler that used star cutters and (2) a 3-piston hammer with reciprocating bits. The hand-held tools were used in conjunction with the LTC PTC-6 vacuum system which captured dust and debris as the wall decontamination took place.

The PTC-6 is a vacuum system designed to be used with surface decontamination equipment. Dust and debris are captured by a high efficiency particulate air filter (HEPA) vacuum system that deposits the waste directly into an on-board 23-gallon waste drum. The PTC-6 utilizes compressed air delivered, from a source, via a hose connected to the air inlet, to drive the hand-held power tools. The air is delivered to the

Figure 1. PTC-6 vacuum system used with hand tools for wall decontamination.

tools by air hoses which are attached to the control panel. The control panel regulates the air pressure delivered to the tool. A separate compressed air flow powers the vacuum generator. The vacuum hoses connect the power tools to the dust chamber, returning paint chips and dust from the surface. A third compressed air flow is used to clean filters by pulsing air through a pipe with slots. The blasts of air shake dust and debris from the filter fabric.

Due to the high humidity environment in which the testing demonstration took place, LTC used an air dryer in-line with the system. This is not required for operation but is intended to keep the air lines free of moisture.

SECTION 3 - HEALTH AND SAFETY EVALUATION

General Health and Safety Concerns

Personnel where the LTC wall decontamination technology is being used need to be concerned with safety and health issues. Issues that personnel need to be cognizant of may be divided into two categories. First, core issues are those that are based on current safety and health regulatory requirements. Second, best management practices are related to issues that are not based on current safety and health regulations, but are key elements in preventing worker injury and illness on the job.

Safety and health issues of concern with the LTC wall decontamination technology included:

Core Issues:

- ◆ Tripping hazards - Although necessary, air lines and vacuum hoses needed to operate the equipment are tripping hazards. Stringent housekeeping must be addressed.
- ◆ Lockout/tagout - The user of the technology will need to develop a lockout/tagout program to assure there is not an accidental release of energy during maintenance/repair activities.

- ◆ One of the hand-held tools had a slide on/slide off switch which did not require the operator to maintain pressure on it to keep it in the "on" position. When the tool is lifted from the surface, it may continue to run. This has the potential to cause severe injury.
- ◆ Noise - The user was subjected to an excessive amount of noise while operating the hand-held tools used during the testing demonstration.
- ◆ Dust - The equipment did not generate visible dust during operation. However, larger debris was left on the floor surface. The amount of dust generated in the breathing zone of the operator may change based on the environment in which the wall decontamination is taking place, therefore, the user of the technology will need to develop a sampling plan based on the individual site needs. It should also be noted that there was potential for contamination to dust when changing filters and during drum change activities with the PTC-6.
- ◆ Working at heights - Due to the nature of the work, i.e. wall decontamination, it is necessary to work from scaffolding and compliance with OSHA scaffolding regulations must be assured.

Best management practices:

- ◆ Heat stress - The operator would potentially be subjected to an increase in heat stress due to the need to utilize personal protective equipment (PPE). The user will need to develop a heat stress program for the environment in which the technology is being used, taking into consideration any PPE that may need to be utilized, ambient temperatures, etc.
- ◆ Ergonomics - There are several ergonomic concerns with the hand-held tools used for wall decontamination. This includes lifting, bending, twisting, kneeling, stooping, and wrist, hand, arm, shoulder, and back stress and abnormal positioning. In addition, the force required to keep the tool in contact with the wall is of concern. When full drums are being changed on the PTC-6, mechanical lifting devices need to be utilized.

There are several ergonomic concerns associated with the operator working on the lower portion of the wall. The operator is required to stoop, kneel, squat, and assume several other awkward positions to reach the lowest portion of the wall. This may also increase exposure to contaminants by coming in contact with the walking surface where contaminants have fallen during the wall decontamination.

- ◆ Arm-hand vibration – Through observational techniques, it was noted that the user was subjected to excessive arm-hand vibration during operation of the hand-held tools. This type of vibration has the potential to lead to health problems, such as Raynaud's Syndrome.
- ◆ Struck by hazards - The air lines have the potential to cause severe injury if their fittings were to fail. A safety line between the male and female end of the fittings would prohibit the line from becoming airborne.
- ◆ Communication - Due to the noise generated by the technology during operation, communication could be difficult. Personnel working in the area should be knowledgeable of and proficient in the use of hand signals when needed.

INDUSTRIAL HYGIENE MONITORING

During the testing demonstration with the PTC-6 wall decontamination system, sampling was conducted for dust and noise. In addition, the wet-bulb globe temperature was monitored to evaluate heat stress. Observational evaluation was conducted for ergonomics and arm-hand vibration.

Through general observational techniques the potential for ergonomic problems was evaluated during the testing demonstration. There is potential for muscle/back stress and/or injuries due to bending, twisting, and lifting associated with setup, operation, maintenance, and decontamination. There is a potential for wrist, hand, arm, and shoulder injury due to the awkward positions required during operation of the hand-held tools. This was evident by the operator constantly changing hand position while using the equipment. The back (lower and upper), arms, and shoulders appeared to have additional stress placed on them due to the pressure being applied by the worker, to keep the face plate and the cutter/hammers of the hand-held tools against the wall surface.

Exposure to arm-hand vibration was present throughout the operation of the hand-held tools. While arm-hand vibration was not quantitatively measured, it was readily apparent that there was exposure that could potentially cause health problems, such as Raynaud's Syndrome. Some whole-body vibration was also present during operation due to the vibration of the wall and associated walking surface in the area.

Heat stress parameters were monitored using a Quest QuestTemp®15 Heat Stress Monitor. The wet-bulb globe temperature was used to determine the work/rest regimen in accordance with the American Conference of Governmental Industrial Hygienist (ACGIH) recommendations. The wet-bulb globe temperature was adjusted in

accordance with ACGIH guidelines for the type of clothing, including PPE, that the worker was wearing.

While heat stress will be increased when wearing PPE, the overall heat stress response will vary from worker to worker. Each situation in which the technology is used will need to be evaluated for the heat stress potential, taking into consideration the wet-bulb globe temperature, PPE in use, physical condition of the worker, and amount of worker acclimatization.

Dust monitoring was conducted with a sampling train consisting of an SKC IOM Inhalable dust sampler coupled with an MSA Escort Elf air sampling pump. Pre- and post-sampling calibration was accomplished using a BIOS International DryCal DC1 primary calibration system. Sampling filters were desiccated pre- and post-sampling and weighed on an OHAUS Scout Electronic Balance. Sampling was conducted in accordance with NIOSH method 0500.

Personal air sampling was conducted on the equipment operators during the wall decontamination demonstration. Personal dust sampling values of 28.60 mg/m³ and 0.00 mg/m³ were obtained for Operator No. 1 and 30.82 mg/m³ and 0.00 mg/m³ for Operator No. 2. One value for each operator exceeds the Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) and the ACGIH threshold limit value (TLV) of 15 mg/m³ and 10 mg/m³ respectively for total dust. This may be accounted for by large pieces of concrete debris that was visible on the sampling filters on the day when the dust results were elevated. This occurred on the first day of the wall decontamination demonstration. The next day, the sampling results showed no dust accumulation and there was no visible debris on the filters. This may, in part, be attributed to the operators adjusting to using the hand-held tools on the wall surface. This illustrates the importance of worker training to include instructing the worker on developing and using work habits that keep him/her from exposure to hazards.

Additionally, there were larger pieces of debris left on the walking surface. This debris could potentially become airborne and, therefore, become an inhalation hazard. Due to this and the dust sampling being conducted in a semi-open environment, it is recommended that sampling be conducted while the wall decontamination operation is being carried out in a closed environment. A complete air sampling plan for a site would need to be developed to include not only dust but other contaminants specific to the wall decontamination project. (See Appendix B for sampling data.)

Personal noise monitoring was conducted using a Metrosonic db-3100 data logging noise dosimeters. Calibration was conducted pre- and post-monitoring using a Metrosonics CL304 acoustical calibrator. Monitoring was conducted on Operator No. 1 for 3.05 hours (183 minutes) and on Operator No. 2 for 3.33 hours (200 minutes).

Monitoring during this time showed a noise dose of 209.54% which gives an 8-hour time weighted average (TWA) of 95.3 dBA for operator number 1. If Operator No. 1 continued to have this same level of noise exposure during the entire 8-hour shift, a projected noise dose would be 548.97% (TWA -102.3 dBA).

Monitoring for Operator No. 2 showed a noise dose of 236.96% (TWA - 96.2 dBA). If Operator No. 2 continued to have this same level of noise exposure during the entire 8-hour shift, a projected noise dose would be 568.24% (TWA -102.5 dBA).

The OSHA allowable PEL for noise is a 100% dose or an 8-hour TWA of 90 dBA. The operators were overexposed after all periods of time. At these exposure levels, personnel would be required to be included in a hearing conservation program. Feasible engineering controls, administrative controls, and personal protective equipment (PPE-hearing protection devices) need to be used. The noise levels produced by the wall decontamination system may require that engineering and administrative controls, as well as hearing protection devices, all be simultaneously employed to control the noise level. The percentage of time spent at each loudness level that comprises the exposures can be seen in Appendix B.

During monitoring, the noise levels were averaged for each one minute period of time, and then an overall average was calculated. An average exposure level of 102.3 dBA was obtained for Operator No. 1 and 102.5 dB for Operator No. 2. The maximum sound level measured for Operator No. 1 was 116.4 dB and 114.7 dB for Operator No. 2. The peak exposure seen for Operator No. 1 was 142.9 dB and for Operator No. 2, 135.8 dB.

These measurements define noise as an extreme exposure hazard for personnel operating the LTC wall decontamination technology. It must also be noted that the equipment was being operated in a semi-open structure at the time of the measurements. Operation in a facility that is fully enclosed will have the potential to increase the noise level due to other influences such as vibration and reverberation.

HUMAN FACTORS INTERFACE

The need to utilize different levels of personal protective equipment, such as Level A, B, C, or D will depend on the contaminants associated with the wall being decontaminated. These contaminants should be identified by the site characterization prior to the start of the wall decontamination job.

The level of protection being utilized has the potential to cause several human factors interface problems. These may include but not be limited to visibility, manual dexterity, tactile sensation, an increase in heat stress, and an overall increase in physical stress.

The amount of arm-hand vibration the operator was receiving during operation of the hand-held tools creates an additional human factors interface issue. It is recommended that further evaluation with quantitative measurements of arm-hand vibration be conducted for this equipment.

TECHNOLOGY APPLICABILITY

On observation the technology did not generate visible dust and air monitoring did not show a significant dust level. This was, however, difficult to assess due to the semi-open testing environment. Additionally, there were larger pieces of debris left on the surface during wall decontamination activities. The system needs to be evaluated to determine if an increase in capture velocity across the vacuum pick up slot would help with this problem.

The hand-held tools and PTC-6 vacuum system will need to be disassembled to be decontaminated. This will not necessarily guarantee that decontamination will be complete. Many parts, such as the hoses, star cutters, and hammers may need to be considered consumables.

SECTION 4 – JOB SAFETY ANALYSIS

JOB SAFETY ANALYSIS LTC AMERICAS, INC. PTC-6 VACUUM SYSTEM (WALL DECONTAMINATION)

HAZARD	CORRECTIVE ACTION
UNLOADING EQUIPMENT/SETUP	
* Pinch Points	* Use of hand protection * Use of proper hand-held tools for the job
* Slips/Trips/Falls	* Awareness of the specific hazards * Organization of materials (housekeeping) * Walking around areas that are congested/slippery when possible * Walking around tripping hazards when possible * Marking, isolating, bunching together tripping hazards such as vacuum hoses
* Struck by/Caught between	* Awareness of where equipment is being moved to at all times * Prohibit worker from being between moving and stationary objects at all times * Keep personnel clear of moving objects * Use of proper warning devices on equipment
* Restricted Communication (associated with noise)	* Hand signals as SOP's
* Muscular/Back Injury	* Ergonomic training including safe lifting techniques * Use of equipment such as forklift or crane for unloading

WALL DECONTAMINATION – HAND-HELD TOOLS	
* Slips/Trips/Falls	<ul style="list-style-type: none"> * Awareness of site specific hazards/cords/tether lines/etc. * Job site organization of materials (housekeeping) * Walk around hazards when possible * Marking, isolating, bunching together tripping hazards such as vacuum hoses
* Noise	<ul style="list-style-type: none"> * Use engineering controls * Use administrative controls * Provide proper PPE devices/training
* Exposure to Arm/Hand Vibration	<ul style="list-style-type: none"> * Use of anti-vibration PPE such as gloves * Ergonomic training to include arm/hand vibration
* Pinch Points	<ul style="list-style-type: none"> * Use of hand protection * Remote operations when possible
* Muscular/Back Injury	<ul style="list-style-type: none"> * Limit duration of work * Use extended tools * Training on proper lifting techniques * Reducing force necessary (by workers) to keep the face plate and cutters/hammers in contact with wall surface
* Struck by coating/substrate being removed	<ul style="list-style-type: none"> * Wear appropriate PPE; glasses, face shield, gloves, long sleeves, etc. * Interlock system which shuts tools off when contact with surface is lost
* Accidental activation of moving parts	<ul style="list-style-type: none"> * Use proper lockout/tagout procedures when changing heads on hand-held tools * Do not use hands to clear cutters/hammers * Install two-hand starting mechanism * Keep hands/fingers away from moving rotating cutters/hammers

CHANGING DRUM	
* Slips/Trips/Falls	<ul style="list-style-type: none"> * Awareness of the specific hazards * Organization of materials (housekeeping) * Walking around areas that are congested/slippery when possible * Walking around tripping hazards when possible * Marking, isolating, bunching together tripping hazards such as vacuum lines
* Pinch Points	<ul style="list-style-type: none"> * Use of hand protection * Use of hand tools appropriate for the job
* Accidental Activation	<ul style="list-style-type: none"> * Use of proper lockout/tagout procedures
* Muscular/Back Injury	<ul style="list-style-type: none"> * Handles on drums * Use of mechanical lifting device * Ergonomic training to include proper lifting techniques
GENERAL MAINTENANCE	
* Exposure to contaminant	<ul style="list-style-type: none"> * Wear proper PPE, including respiratory protection * Have something to sit or kneel on so do not have additional personnel exposure from sitting or kneeling on contaminated surface * Change entire cutting head (on hand-held tools) and disassemble, decontaminate and remove head to "clean" area to change cutters
* Accidental activation of moving parts	<ul style="list-style-type: none"> * Use proper lockout/tagout techniques
* Pinch Points	<ul style="list-style-type: none"> * Use of hand protection * Use of hand-held tools appropriate for the job * Use of appropriate lockout/tagout procedures

<ul style="list-style-type: none"> * Slips/Trips/Falls 	<ul style="list-style-type: none"> * Awareness of the specific hazards * Organization of materials (housekeeping) * Walking around areas that are congested/slippery when possible * Walking around tripping hazards when possible
<ul style="list-style-type: none"> * Ergonomics (Bending/Kneeling/Lifting) Lifting 	<ul style="list-style-type: none"> * Limit duration of work * Use proper lifting techniques * Perform maintenance on elevated work platform * Ergonomics training to include proper lifting techniques

SECTION 5 – FAILURE MODE AND EFFECTS ANALYSIS

FAILURE MODE AND EFFECTS ANALYSIS LTC AMERICAS, INC. PTC-6 VACUUM SYSTEM (WALL DECONTAMINATION)

FAILURE MODE	EFFECT
* Lose vacuum pressure	* Potential for higher concentration of contaminant to be released into atmosphere
* Vacuum line is punctured/ruptured or comes loose	* Potential for higher concentration of contaminant to be released into atmosphere * Reduced capture/velocity
* Airline is punctured/ruptured or comes loose	* Potential for injury for worker from airline striking body
* Lose power (from air compressor)	* Equipment shuts down with potential to momentarily release higher concentration of contaminant into atmosphere
* Bag fails when changing out roughing filters	* Potential for exposure to contaminant

SECTION 6 – TECHNOLOGY SAFETY DATA SHEET

TECHNOLOGY SAFETY DATA SHEET

LTC AMERICAS, INC.

PTC-6 VACUUM SYSTEM (WALL DECONTAMINATION)

SECTION 1: TECHNOLOGY IDENTITY

Manufacturer's Name and Address:

LTC Americas, Inc.
22445 Davis Drive
Suite 142
Sterling, VA 20164

Emergency Contact:

Bob Miller
800-822-2332

Information Contact:

Bob Miller
800-822-2332

Date Prepared:

Other Names:

LTC Wall Decontamination System
PTC-6 Vacuum System

Signature of Preparer:

Operating Engineers National Hazmat
Program
1293 Airport Road, Beaver, WV 25813
phone 304-253-8674, fax 304-253-1384

Under cooperative agreement DE-FC21-
95 MC 32260

SECTION 2: PROCESS DESCRIPTION

The LTC wall decontamination technology consisted of two different pneumatic hand-held tools: (1) a roto-peen scaler that used star cutters; and (2) a 3-piston hammer with reciprocating bits. The hand-held tools were used in conjunction with the LTC PTC-6 vacuum system which captured dust and debris as the wall decontamination took place.

The PTC-6 is a vacuum system designed to be used with surface decontamination equipment. Dust and debris are captured by a HEPA vacuum system that deposits the waste directly into an on-board 23-gallon waste drum. The PTC-6 utilizes compressed air delivered, from a source, via a hose connected to the air inlet, to drive the hand-held power tools. The air is delivered to the tools by air hoses which are attached to the control panel. The control panel regulates the air pressure delivered to the tool. A separate compressed air flow powers the vacuum generator. The vacuum hoses connect the power tools to the dust chamber, returning paint chips and dust from the surface. A third compressed air flow is used to clean filters by pulsing air through a pipe with slots. The blasts of air shake dust and debris from the filter fabric.

When being used in a high humidity environment, the system may be used with an air dryer in-line. This is not required for operation but is intended to keep the air lines free of moisture.

SECTION 3: PROCESS DIAGRAM

PTC-6

SECTION 3: PROCESS DIAGRAM

SERVICE LAYOUT

PEENING PREP TOOL (PPT)

SECTION 4: CONTAMINANTS AND MEDIA

The technology has the potential to cause dust and associated contaminants to become airborne. Specific contaminants need to be evaluated on a site-by-site, job-by-job basis to determine the potential for exposure.

SECTION 5: ASSOCIATED SAFETY HAZARDS

Probability of Occurrence of Hazard:

- 1 Hazard may be present but not expected over background level
- 2 Some level of hazard above background level known to be present
- 3 High hazard potential
- 4 Potential for imminent danger to life and health

A. ELECTRICAL (LOCKOUT/TAGOUT)	RISK RATING: 2
---------------------------------------	-----------------------

The vacuum system and hand-held tools are pneumatically operated. The air compressor used may be electrical or diesel powered. If the air compressor is electrical, appropriate precautions such as ground fault circuit interrupters, proper grounding, etc. will need to be considered.

B. FIRE AND EXPLOSION	RISK RATING: 1
------------------------------	-----------------------

Technology does not pose this hazard in and of itself but could not be used in an explosive environment due to the potential for sparking. Related air compressor may be of concern.

C. CONFINED SPACE ENTRY	RISK RATING: 1
--------------------------------	-----------------------

Not part of this technology unless the specific location where the hand-held tools are being used is a confined space. In this case, confined space procedures would need to be followed.

D. MECHANICAL HAZARDS	RISK RATING: 4
------------------------------	-----------------------

Use of large equipment and hand-held tools may pose the following: pinch points, struck by, and caught between hazards and fall from above. One of the hand-held tools has a slide on/slide off switch that does not require the operator to maintain pressure on it to keep it in the "on" position. When the tool is lifted from the surface, it may continue to run. This has the potential to cause severe injury.

E. PRESSURE HAZARDS	RISK RATING: 3
----------------------------	-----------------------

Technology presents hazards from air lines. If a fitting were to fail, a severe struck-by injury could be caused by a loose line.

F. TRIPPING AND FALLING	RISK RATING: 3
--------------------------------	-----------------------

Air lines and vacuum hoses present hazards.

G. LADDERS AND PLATFORMS	RISK RATING: 4
<p>Due to the nature of the work associated with the technology, i.e. wall decontamination, it is necessary to work at a height. This presents the potential for an object falling from above to injure workers at ground level. Proper precautions must be taken.</p> <p>Reaching the top portion of the wall requires the use of scaffolding. Proper precautions must be taken including compliance with the OSHA scaffold standard, falling object protection, and training. No one should be permitted to work in the area of the scaffolding without a hard hat.</p>	
H. MOVING VEHICLES	RISK RATING: 3
<p>The presence of multiple pieces of mobile equipment (used to unload and load the technology) in relationship to a small area of operation may pose a significant danger. Sufficient warning devices such as horns, bells, lights and back up alarms should be utilized. Personnel should be trained to work with and around moving equipment.</p>	
I. BURIED UTILITIES, DRUMS, AND TANKS	RISK RATING: N/A
<p>Not part of this technology.</p>	
J. PROTRUDING OBJECTS	RISK RATING: N/A
<p>Not part of this technology.</p>	
K. GAS CYLINDERS	RISK RATING: N/A
<p>Not part of this technology.</p>	
L. TRENCHING AND EXCAVATIONS	RISK RATING: N/A
<p>Not part of this technology.</p>	
M. OVERHEAD LIFTS	RISK RATING: 3
<p>Unloading and loading of technology may require overhead lifts or the use of a forklift. Proper precautions indicated.</p>	
N. OVERHEAD HAZARDS	RISK RATING: 3
<p>Would be present if a crane were required to unload or load equipment. Due to the nature of the work associated with the technology, i.e. wall decontamination, it is necessary to work at a height. This presents the potential for an object falling from above to injure workers at ground level. Proper precautions must be taken.</p>	

SECTION 6: ASSOCIATED HEALTH HAZARDS	
A. INHALATION HAZARD	RISK RATING: 3
Technology produces dust from the coating being removed and could produce dust associated with the substrate. Specific hazards will be identified from the site characterization. Total dust and/or respirable dust generated needs to be evaluated, as well as the specific contaminants associated with the coatings and surface being decontaminated.	
B. SKIN ABSORPTION	RISK RATING: 1
This would be dependent on the contaminants at the site and would be identified by the site characterization.	
C. HEAT STRESS	RISK RATING: 4
Ambient conditions correlated with PPE, work/rate, etc. must be considered.	
D. NOISE	RISK RATING: 4
The technology presents an excessive noise hazard.	
E. NON-IONIZING RADIATION	RISK RATING: N/A
Not part of this technology.	
F. IONIZING RADIATION	RISK RATING: N/A
Not part of this technology, but may be associated with the surface being decontaminated.	
G. COLD STRESS	RISK RATING: 1
Technology does not produce a hazard, but ambient conditions need to be considered.	
H. ERGONOMIC HAZARDS	RISK RATING: 3
Poses ergonomic hazards associated with lifting, bending, twisting, stooping, kneeling. These may cause injury/strain to the back, knees, hips, and/or legs. Also ergonomic hazards to the wrists/hands, arms, and shoulders are possible from operation of the hand-held tools.	
I. OTHER	RISK RATING: 3
Poses a hazard due to arm/hand vibration from operating the hand-held tools. This may lead to associated health problems such as Raynaud's Syndrome.	

SECTION 7: PHASE ANALYSIS

A. CONSTRUCTION/START-UP

The set-up/start-up phase presents several hazards including pinch points, slips/trips/falls, struck by/caught between, falling from above, muscular/back injury, and electrical hazards.

B. OPERATION

The operational phase presents several hazards including exposure to contaminant (airborne and from the surface); arm/hand vibration; muscular/back injury; wrist/hand, arm, and shoulder injury; whole-body vibration; mechanical hazards; and excessive exposure to noise.

C. MAINTENANCE

The maintenance phase presents several hazards including pinch points, slips/trips/falls, struck by/caught between, muscular/back injury, exposure to contaminants (airborne and from the surface), and accidental activation of moving parts.

D. DECOMMISSIONING

The decommissioning phase presents several hazards including exposure to the contaminant, pinch points, slips/trips/falls, and muscular/back injury.

SECTION 8: HEALTH AND SAFETY PLAN REQUIRED ELEMENTS

A. AIR MONITORING

When concrete walls are scabbled, total dust and respirable dust need to be monitored. Monitoring also needs to be done for specific concrete contaminants and may need to be conducted for specific constituents of the concrete such as silica. In addition, noise monitoring is essential.

B. WORKER TRAINING

Training that would apply in this case may include but not be limited to: HAZWOPER (Hazardous Waste Operations and Emergency Response), HAZCOM (Hazard Communication), Respiratory Protection, Hearing Conservation, Ergonomics (proper lifting, bending, stooping, kneeling, and arm/hand vibration, Heat Stress (learning to recognize signs and symptoms), Personal Protective Equipment, Emergency Response/Bloodborne Pathogens, Lockout/Tagout, Hand Signal Communication, Construction Safety (OSHA 500), and/or General Industry Safety (OSHA 501).

C. EMERGENCY RESPONSE	Emergency response planning for a site needs to assure adequate coverage for hazards described in the TSDS. Having at least one person per shift trained in CPR and first aid is recommended.
D. MEDICAL SURVEILLANCE	Evaluation of personnel's general health with emphasis on the cardiovascular and respiratory system, back, and peripheral nervous system. Medical surveillance in accordance with the OSHA standards needs to be conducted. Initial and annual audiograms.
E. INFORMATIONAL PROGRAM	Workers must be trained in specific operation of equipment before use.

SECTION 9: COMMENTS AND SPECIAL CONSIDERATIONS	Due to the noise produced, communication may become difficult. Personnel working in the area should be familiar with and use hand signals as necessary. Only personnel who have been adequately trained in the operation of this technology should be permitted to operate and/or work with the equipment.
---	---

SECTION 7 - EMERGENCY RESPONSE/PREPAREDNESS

The use of the LTC wall decontamination technology would not be applicable to use in an emergency response situation.

Emergency response/preparedness must be part of every hazardous waste site safety and health plan. In addition to credible site emergencies, site personnel must plan for credible emergencies in connection with the LTC wall decontamination.

All precautions used when responding to an emergency situation at the site will apply. Before entering an area where the PTC-6 vacuum system is being used, the equipment needs to be completely shut down (de-energized).

This technology does not appear to present any conditions that would lead to out of the ordinary emergencies.

SECTION 8 - REGULATORY/POLICY ISSUES

The site safety and health personnel where the LTC wall decontamination technology is being used need to be concerned with safety and health regulations applicable to the issues discussed above. Regulations that apply may be divided into four categories. First, core requirements are those regulations that would apply to any hazardous waste work site, regardless of the type of job. Second, technology-specific requirements are those regulations that apply due to the specific technology being used. Third, special requirements are standards and policies that are specific to the technology itself, and are required by reference in a regulation. Fourth, best management practices are not required but are recommended by organizations such as the American National Standards Institute (ANSI), the National Institute of Occupational Safety and Health (NIOSH), Department of Energy (DOE), National Fire Protection Association (NFPA), etc. These regulations/standards may include, but not be limited to, the following:

Core requirements:

- ◆ OSHA 29 CFR 1926.25 Housekeeping
- ◆ OSHA 29 CFR 1910.141 Sanitation (1910.141(a)(3) covers housekeeping)

- ◆ OSHA 29 CFR 1926 Subpart Z Toxic and Hazardous Substances
- ◆ OSHA 29 CFR 1910 Subpart Z Toxic and Hazardous Substances
- ◆ OSHA 29 CFR 1926.59 Hazard Communication
- ◆ OSHA 29 CFR 1910.1200 Hazard Communication
- ◆ OSHA 29 CFR 1926.64 Process Safety Management of Highly Hazardous Chemicals
- ◆ OSHA 29 CFR 1910.119 Process Safety Management of Highly Hazardous Chemicals
- ◆ OSHA 29 CFR 1926.65 Hazardous Waste Operations and Emergency Response
- ◆ OSHA 29 CFR 1910.120 Hazardous Waste Operations and Emergency Response
- ◆ Occupational Safety and Health Act 1970(5)(a)(1) General Duty Clause

Technology specific requirements:

- ◆ OSHA 29 CFR 1926 Subpart L Scaffolding
- ◆ OSHA 29 CFR 1910.28 Safety Requirements for Scaffolding
- ◆ OSHA 29 CFR 1926 Subpart I Tools-Hand and Power
- ◆ OSHA 29 CFR 1910 Subpart P Hand and Portable Powered Tools and Other Hand-Held Equipment
- ◆ OSHA 29 CFR 1910 Subpart O Machinery and Machine Guarding
- ◆ OSHA 29 CFR 1910.147 The Control of Hazardous Energy (Lockout/Tagout)
- ◆ OSHA 29 CFR 1926.52 Occupational Noise Exposure
- ◆ OSHA 29 CFR 1910.95 Occupational Noise Exposure
- ◆ OSHA 29 CFR 1926.103 Respiratory Protection

- ◆ OSHA 29 CFR 1910.134 Respiratory Protection
- ◆ OSHA 29 CFR 1926.102 Eye and Face Protection
- ◆ OSHA 29 CFR 1910.133 Eye and Face Protection
- ◆ OSHA 29 CFR 1926.28 Personal Protective Equipment
- ◆ OSHA 29 CFR 1910.132 Personal Protective Equipment
- ◆ OSHA 29 CFR 1910.132 General Requirements (Personal Protective Equipment)
- ◆ OSHA 29 CFR 1926.23 First Aid and Medical Attention
- ◆ OSHA 29 CFR 1910.151 Medical Services and First Aid
- ◆ OSHA 29 CFR 1910.1000 Toxic and Hazardous Substances

Best management practices:

- ◆ ANSI S3.34-1986 Guide for the Measurement and Evaluation of Human Exposure to Vibration Transmitted to the Hand
- ◆ ACGIH Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices
- ◆ NIOSH Revised Lifting Equation, 1994

In addition to the above regulations and policies, it is imperative that all workers have appropriate and adequate training for the task and associated safety and health conditions. Training that would be required may be divided into four categories. Core training is that which is required for anyone entering a hazardous waste site to perform work, regardless of the type of job. Technology specific training is that training that is specific to the technology and required by safety and health standards. Special training is that which is specific to the technology to assure the worker is adequately trained for the task but is not necessarily required by safety and health standards. Best management practices are trainings that while not mandated by health and safety standards, provide information and knowledge to the worker that will allow the worker to perform the job safely. Training to be applied for the LTC PT6-Vacuum System may include but not be limited to:

Core training requirements:

- ◆ HAZWOPER
- ◆ HAZCOM

Technology Specific training:

- ◆ Scaffolding
- ◆ Respiratory Protection
- ◆ Hearing Conservation
- ◆ Personal Protective Equipment
- ◆ Lockout/Tagout

Special training:

- ◆ Job specific training for equipment operation

Best Management Practice training:

- ◆ Ergonomics (proper lifting, bending, stooping, kneeling, arm-hand vibration)
- ◆ Heat stress (learning to recognize signs and symptoms)
- ◆ CPR/First Aid/Emergency Response/Bloodborne Pathogens
- ◆ Electrical Safety
- ◆ Hand Signal Communication
- ◆ Construction Safety (OSHA 500) and or General Industry Safety (OSHA 501)

SECTION 9 - OPERATIONAL CONSIDERATIONS & RECOMMENDATIONS

Recommendations made in this section for improved worker safety and health take into consideration the operation of the hand-held tools with the LTC PTC-6 vacuum system. Specific recommendations include:

- ◆ It needs to be assured that workers are aware of the tripping hazards associated with air and vacuum hoses that are necessary to operate the equipment. Keeping these as orderly as possible in compliance with good housekeeping regulations will help avoid injury due to tripping.
- ◆ The vacuum hoses were not connected to the outlet on the pieces of hand-held tools by means of a clamping system. This could allow the hoses to be pulled loose and create an exposure to the contaminant. Hoses should be attached with some type of clamping system to reduce the possibility that they will become detached accidentally.
- ◆ The operators of the equipment need to have training in ergonomics to assure proper techniques in lifting, bending, stooping, twisting, etc. during equipment operation. In addition, training needs to include discussion on ergonomics associated with the wrists/hands, arms, and shoulders when using hand-held tools. The tools themselves need to be evaluated for ergonomic design to enable the worker to use them without having to place themselves in awkward positions or to place an excessive amount of force against the tool to keep it in contact with the wall. For example, the workers had to place their hands on the housing of the one hand-held tool to move and control it because the handle was not in the best position. A better design to include a movable handle would allow the worker to move it to the required position.
- ◆ If a fitting on an air line fails, the flying hose has the potential to cause severe injury. A safety line connected to the male and female parts of the fitting would keep the hose from becoming a flying object.
- ◆ A full 23-gallon drum may weigh 220 pounds or more and a 55-gallon drum even more. This presents great potential for back injury when two operators lift the drum for change out. It is recommended that the system be evaluated for use with a mechanical lifting system.
- ◆ The cleaning (blow back) of the filters was a manual operation. If this were automated to occur at set intervals of time, the operation would be more efficient and reduce the possibility of worker exposure.

- ◆ Noise exposure was above the PEL during operation of the PTC-6 system. Since testing was done in a semi-open three walled structure, it is plausible that the noise levels would increase in a fully enclosed environment. The equipment needs to be evaluated for possible engineering controls to help decrease the noise exposure to the operator. If engineering controls are not possible, administrative controls, and/or adequate hearing protection must be incorporated during operation.

- ◆ Wall decontamination requires that the worker be able to reach the top and the bottom portions of the walls to decontaminate them. Decontamination of the bottom portion of the wall requires the worker to assume awkward positions such

Figure 2. Worker decontaminating lower portion of the wall using star-cutters.

as stooping, squatting, bending, or kneeling, which also causes contact with the potentially contaminated walking surface. A longer handle on the hand-held tool or an adjustable stool would allow this to be accomplished without having to assume the awkward positions and/or come in contact with the walking surface.

Reaching the top portion of the wall requires the use of scaffolding. Proper precautions must be taken including compliance with the OSHA scaffold regulation, falling object protection, and training. No one should be permitted to work in the area of the scaffolding without a hard hat. The worker on the scaffolding was having to put a large amount of force against the hand-held tool to hold it against the wall. This was accomplished by using his body weight to push against the tool. In addition to ergonomic concerns, this has the potential to move or tip the scaffolding and should be avoided. A better method would be engineering the tool to require less pressure to keep it in contact with the wall, such as appropriately located handles for vertical work. Attaching the scaffolding to the wall would also alleviate this concern.

Figure 3. Worker decontaminating upper portion of wall using star-cutters.

- ◆ It must be noted that a ladder (which was not used during the testing demonstration) would not be appropriate for this type of work. Three-points of contact could not be maintained while using the hand-held tools.

- ◆ Due to the high humidity environment in which the testing demonstration took place, LTC used an air dryer in-line with the system. This is not required for operation but was intended to keep the air lines free of moisture. There was, however, water dripping from the unit. This created a slippery walking surface and had the potential to create a secondary waste problem. Preventative maintenance and assuring all components are in working order is of utmost importance. In addition, a method for catching or containing the dripping water or placing the unit outside of the contaminated area would help with these problems.
- ◆ The star cutters had to be changed frequently. The worker must handle many sharp star-shaped disks. The sharp edges have the potential to cut the worker's gloves which in turn increases the worker's potential for not only being cut, but also being exposed to contaminants. Providing several tool cutter heads with the star cutters already in place would be a better method. This would allow the heads to be changed in the contaminated area and the old cutter head could be decontaminated and removed to the "clean area" to change the star cutters. If the star cutters have to be changed while they are contaminated, gloves to prohibit cutting may need to be worn in addition to gloves for protection against the contaminant.
- ◆ There was visible sparking seen when the star cutter was being used on the concrete wall. This would prohibit this hand-held tool from being used in an explosive atmosphere or around any potential ignition sources.
- ◆ The vacuum hose, which is 1½ - 2 inches in diameter and is attached to the back of the star cutter hand-held tool (which was being used from the scaffolding), added weight to the tool and pulled in a downward direction. This increases ergonomic stressors placed on the worker. Some type of hook on the railing of the scaffolding to support the vacuum hose and keep it from pulling would help with this problem.

Due to the semi-open three walled environment in which the testing demonstration was conducted and, therefore, the dust monitoring was conducted, it is recommended that further testing for dust exposure be conducted while the technology is used in a closed environment similar to environments in which it would be used at a hazardous waste clean-up site. It is also recommended that noise monitoring be conducted while the technology is used inside a fully enclosed environment. This would also allow for an evaluation of the heat stress to be encountered while wearing the appropriate PPE in different environments.

The safety and health issues discussed throughout this report could be reduced and, in some cases, eliminated if this type of wall decontamination technology could operate remotely.

APPENDIX A REFERENCES

Occupational Safety and Health Standards for General Industry, 29 CFR Part 1910, Occupational Safety and Health Administration United States Department of Labor

Occupational Safety and Health Standards for the Construction Industry, 29 CFR Part 1926, Occupational Safety and Health Administration United States Department of Labor

Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents and Biological Exposure Indices (BEIs), American Conference of Governmental Industrial Hygienists, 1995-1996

ANSI 1986, Guide for the measurement and evaluation of human exposure to vibration transmitted to the hand, New York, NY: American National Standards Institute, ANSI S3.34

The NIOSH compendium of hearing protection devices, U.S. Department of Health and Human Services, Public Health Service, Center for Disease Control and Prevention, October 1994

U.S. Department of Health and Human Services, Applications Manual for the Revised NIOSH Lifting Equation, January 1994

APPENDIX B IH SAMPLING DATA

LTC WALL DECONTAMINATION SYSTEM Total Dust Sampling			
Date	Sample Number	Location	Results
7/28/97	072897-FIU-002	Blank	0.00 mg/m ³
7/28/97	072897-FIU-004	Total dust	28.60 mg/m ³
7/28/97	072897-FIU-001	Total dust	30.82 mg/m ³
7/29/97	072997-FIU-003	Blank	0.00 mg/m ³
7/29/97	072997-FIU-006	Total dust	0.00 mg/m ³
7/29/97	072997-FIU-005	Total dust	0.00 mg/m ³

- * The OSHA PEL for total dust is 15 mg/m³ and the ACGIH TLV is 10 mg/m³. Current sampling was conducted for total dust. The need to sample for respirable dust and silica has to be considered during concrete decontamination and decommissioning activities.

NOISE SAMPLING

Amplitude Distribution Data

The percentage of time spent at each decibel level can be obtained from the graph. As shown, 2.539% of the time the noise exposure was less than 85dBA which means only 97.461% of the time was spent at sound levels above 85dBA. OSHA requires that a hearing conservation program be initiated if the 8-hour TWA is 85dBA.

NOISE SAMPLING DATA

Amplitude Distribution Data

The percentage of time spent at each decibel level can be obtained from the graph. As shown, 5.509% of the time the noise exposure was less than 85dBA which means only 94.491% of the time was spent at sound levels above 85dBA. OSHA requires that a hearing conservation program be initiated if the 8-hour TWA is 85dBA.

APPENDIX C ACRONYMS

ACGIH	-	American Conference of Governmental Industrial Hygienists
ANSI	-	American National Standards Institute
DOE	-	Department of Energy
FIU	-	Florida International University
HAZWOPER	-	Hazardous Waste Operations and Emergency Response
HAZCOM	-	Hazard Communication
HEPA	-	high efficiency particulate air filter
NIOSH	-	National Institute of Occupational Safety and Health
NFPA	-	National Fire Prevention Association
OSHA	-	Occupational Safety and Health Administration
PEL	-	permissible exposure limits
PPE	-	personal protective equipment
SOP's	-	standard operating procedures
TLV	-	threshold limit value
TWA	-	time weighted average

1998 MAR 25 P 2: 32

H000E-FETC

LTC AMERICAS, INC.

PTC-6 VACUUM SYSTEM

TABLE OF CONTENTS

ACKNOWLEDGEMENTS.....	ii
EXECUTIVE SUMMARY	iii
SECTION 1 - SUMMARY	1
Technology Description	1
Key Results	1
SECTION 2 - SYSTEM OPERATION.....	1
SECTION 3 - HEALTH AND SAFETY EVALUATION	2
General Health and Safety Concerns	2
Core Issues	2
Best Management Practices.....	3
Industrial Hygiene Monitoring	4
Human Factors Interface	6
Technology Applicability	7
SECTION 4 - EMERGENCY RESPONSE/PREPAREDNESS	7
SECTION 5 - REGULATORY POLICY ISSUES.....	7
Core Requirements	8
Technology Specific Requirements	8
Best Management Practices.....	9
Core Training Requirements.....	10
Technology Specific Training.....	10
Special Training	10
Best Management Practice Training.....	10
SECTION 6 - OPERATIONAL CONSIDERATIONS AND RECOMMENDATIONS	11
APPENDIX A - REFERENCES	14
APPENDIX B - INDUSTRIAL HYGIENE DATA.....	15
APPENDIX C - ACRONYMS	18

ACKNOWLEDGEMENTS

The human factors assessment of LTC Americas, Inc., was conducted under support of the U. S. Department of Energy's Federal Energy Technology Center, under cooperative agreement DE-FC21-95MC32260 with the Operating Engineers National Hazmat Program. The Operating Engineers National Hazmat Program would like to thank the following people for their participation on the "research action team" and the professional expertise they provided for this assessment:

Barbara McCabe
Ralph Pascarella
Pat Bell

Operating Engineers National Hazmat Program
Operating Engineers Local Union 30
Operating Engineers National Hazmat Program

EXECUTIVE SUMMARY

The LTC wall decontamination technology consisted of two pneumatic hand-held tools: (1) a roto-peen scaler that used star cutters and (2) a 3-piston hammer with reciprocating bits. The hand-held tools were used in conjunction with the LTC PTC-6 vacuum system which captured dust and debris as the wall decontamination took place.

The PTC-6 is a vacuum system designed to be used with surface decontamination equipment. Dust and debris are captured by a high efficiency particulate air (HEPA) filter vacuum system that deposits the waste directly into an on-board 23-gallon waste drum. The PTC-6 utilizes compressed air delivered, from a source, via a hose connected to the air inlet, to drive the hand-held power tools. The air is delivered to the tools by air hoses which are attached to the control panel. The control panel regulates the air pressure delivered to the tool. A separate compressed air flow powers the vacuum generator. The vacuum hoses connect the power tools to the dust chamber, returning paint chips and dust from the surface. A third compressed air flow is used to clean filters by pulsing air through a pipe with slots. The blasts of air shake dust and debris from the filter fabric.

During the assessment sampling was conducted for dust and noise and general observational techniques were conducted for ergonomics. General observational techniques for ergonomics showed the potential for some ergonomic problems during wall surface coating removal using the LTC wall decontamination technology. There is potential for muscle/back stress and/or injuries due to bending, twisting, and lifting associated with setup, operation, maintenance, and decontamination. Additionally, there is potential for back muscle sprain/strain from the static postures that had to be assumed to place enough force on the tool to keep it in contact with the wall surface. In addition, arm/hand vibration was noted and needs to be taken into consideration since this type of exposure has the potential to cause injury, such as that associated with Raynaud's Syndrome.

Personal air sampling was conducted on the equipment operators during the wall decontamination demonstration. Personal dust sampling values of 28.60 mg/m³ and 0.00 mg/m³ were obtained for operator Number 1 and 30.82 mg/m³ and 0.00 mg/m³ for operator Number 2. One value for each operator exceeds the Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) and the American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV) of 15 mg/m³ and 10 mg/m³ respectively for total dust. This may be accounted for by the large pieces of concrete debris that was visible on the sampling filters on the day when the dust results were elevated. This occurred on the first day of the wall decontamination demonstration. The next day, the sampling results showed no dust accumulation and there was no visible debris on the filters. This may, in part, be attributed to the operators adjusting to using the hand-held tools on the wall surface. This

illustrates the importance of worker training to include instructing the worker on developing and using work habits that keep him/her from exposure to hazards.

Personal noise monitoring showed noise levels of 209.54% which would give an 8-hour time weighted average (TWA) of 95.3 dBA for operator Number 1 and 236.96% (TWA of 96.2 dBA).

The OSHA allowable PEL for noise is a 100% dose or an 8-hour TWA of 90 dBA. The operators were over exposed during the sampling periods. At these exposure levels, personnel would be required to be included in a hearing conservation program. Feasible engineering controls, administrative controls, and personal protective equipment need to be used. The noise levels produced by the wall decontamination system may require that engineering and administrative controls, as well as hearing protection devices, all be simultaneously employed to control the noise level.

Recommendations for improved worker safety and health during use of the PTC-6 vacuum system with hand-held tools include: 1. keeping all hoses and lines as orderly as possible in compliance with good housekeeping requirements; 2. ergonomic training to include techniques in lifting, bending, stooping, twisting, etc.; 3. use of a clamping system to hold hoses to the vacuum system; 4. a safety line on the air line connections; 5. use of a mechanical lifting system for waste drum removal; and 6. the use of ergonomically designed tools.

LTC Americas, Inc.

PTC-6 Vacuum System (Wall Decontamination)

Human Factors Evaluation

SECTION 1 - SUMMARY

TECHNOLOGY DESCRIPTION

The LTC wall decontamination technology was tested and is being evaluated at Florida International University (FIU) as a baseline technology. In conjunction with FIU's evaluation of efficiency and cost, this report covers the hazard analysis and safety evaluation. The LTC PTC-6 is a commercially available technology and has been used for various projects at locations throughout the country.

The LTC wall decontamination technology consisted of two different pneumatic hand-held tools: (1) a roto-peen scaler that used star cutters; and (2) a 3-piston hammer with reciprocating bits. The hand-held tools were used in conjunction with the LTC PTC-6 vacuum system which captured dust and debris as the wall decontamination took place.

KEY RESULTS

The safety and health evaluation during the testing demonstration focused on two main areas of exposure: dust and noise. Dust exposure was minimal but noise exposure was significant. Further testing for each exposure is recommended because of the semi-open environment where the testing demonstration took place. It is feasible that the dust and noise levels will be higher in a fully enclosed operating environment. It appears that dust and noise surveys will be required in all operational settings where the LTC wall decontamination technology is used. Other areas of concern were arm-hand vibration, ergonomics, heat stress, tripping hazards, pressure line hazards, machine guarding, and lockout/tagout.

SECTION 2 - SYSTEM OPERATION

The LTC wall decontamination technology consisted of two pneumatic hand-held tools: (1) a roto-peen scaler that used star cutters and (2) a 3-piston hammer with reciprocating bits. The hand-held tools were used in conjunction with the LTC PTC-6 vacuum system which captured dust and debris as the wall decontamination took place.

The PTC-6 is a vacuum system designed to be used with surface decontamination equipment. Dust and debris are captured by a high efficiency particulate air filter (HEPA) vacuum system that deposits the waste directly into an on-board 23-gallon waste drum. The PTC-6 utilizes compressed air delivered, from a source, via a hose connected to the air inlet, to drive the hand-held power tools. The air is delivered to the

Figure 1. PTC-6 vacuum system used with hand tools for wall decontamination.

tools by air hoses which are attached to the control panel. The control panel regulates the air pressure delivered to the tool. A separate compressed air flow powers the vacuum generator. The vacuum hoses connect the power tools to the dust chamber, returning paint chips and dust from the surface. A third compressed air flow is used to clean filters by pulsing air through a pipe with slots. The blasts of air shake dust and debris from the filter fabric.

Due to the high humidity environment in which the testing demonstration took place, LTC used an air dryer in-line with the system. This is not required for operation but is

intended to keep the air lines free of moisture.

SECTION 3 - HEALTH AND SAFETY EVALUATION

General Health and Safety Concerns

Personnel where the LTC wall decontamination technology is being used need to be concerned with safety and health issues. Issues that personnel need to be cognizant of may be divided into two categories. First, core issues are those that are based on current safety and health regulatory requirements. Second, best management practices are related to issues that are not based on current safety and health regulations, but are key elements in preventing worker injury and illness on the job.

Safety and health issues of concern with the LTC wall decontamination technology included:

Core Issues:

- ◆ Tripping hazards - Although necessary, air lines and vacuum hoses needed to operate the equipment are tripping hazards. Stringent housekeeping must be addressed.
- ◆ Lockout/tagout - The user of the technology will need to develop a lockout/tagout program to assure there is not an accidental release of energy during maintenance/repair activities.

- ◆ One of the hand-held tools had a slide on/slide off switch which did not require the operator to maintain pressure on it to keep it in the “on” position. When the tool is lifted from the surface, it may continue to run. This has the potential to cause severe injury.
- ◆ Noise - The user was subjected to an excessive amount of noise while operating the hand-held tools used during the testing demonstration.
- ◆ Dust - The equipment did not generate visible dust during operation. However, larger debris was left on the floor surface. The amount of dust generated in the breathing zone of the operator may change based on the environment in which the wall decontamination is taking place, therefore, the user of the technology will need to develop a sampling plan based on the individual site needs. It should also be noted that there was potential for contamination to dust when changing filters and during drum change activities with the PTC-6.
- ◆ Working at heights - Due to the nature of the work, i.e. wall decontamination, it is necessary to work from scaffolding and compliance with OSHA scaffolding regulations must be assured.

Best management practices:

- ◆ Heat stress - The operator would potentially be subjected to an increase in heat stress due to the need to utilize personal protective equipment (PPE). The user will need to develop a heat stress program for the environment in which the technology is being used, taking into consideration any PPE that may need to be utilized, ambient temperatures, etc.
- ◆ Ergonomics - There are several ergonomic concerns with the hand-held tools used for wall decontamination. This includes lifting, bending, twisting, kneeling, stooping, and wrist, hand, arm, shoulder, and back stress and abnormal positioning. In addition, the force required to keep the tool in contact with the wall is of concern. When full drums are being changed on the PTC-6, mechanical lifting devices need to be utilized.

There are several ergonomic concerns associated with the operator working on the lower portion of the wall. The operator is required to stoop, kneel, squat, and assume several other awkward positions to reach the lowest portion of the wall. This may also increase exposure to contaminants by coming in contact with the walking surface where contaminants have fallen during the wall decontamination.

- ◆ Arm-hand vibration – Through observational techniques, it was noted that the user was subjected to excessive arm-hand vibration during operation of the

hand-held tools. This type of vibration has the potential to lead to health problems, such as Raynaud's Syndrome.

- ◆ **Struck by hazards** - The air lines have the potential to cause severe injury if their fittings were to fail. A safety line between the male and female end of the fittings would prohibit the line from becoming airborne.
- ◆ **Communication** - Due to the noise generated by the technology during operation, communication could be difficult. Personnel working in the area should be knowledgeable of and proficient in the use of hand signals when needed.

INDUSTRIAL HYGIENE MONITORING

During the testing demonstration with the PTC-6 wall decontamination system, sampling was conducted for dust and noise. In addition, the wet-bulb globe temperature was monitored to evaluate heat stress. Observational evaluation was conducted for ergonomics and arm-hand vibration.

Through general observational techniques the potential for ergonomic problems was evaluated during the testing demonstration. There is potential for muscle/back stress and/or injuries due to bending, twisting, and lifting associated with setup, operation, maintenance, and decontamination. There is a potential for wrist, hand, arm, and shoulder injury due to the awkward positions required during operation of the hand-held tools. This was evident by the operator constantly changing hand position while using the equipment. The back (lower and upper), arms, and shoulders appeared to have additional stress placed on them due to the pressure being applied by the worker, to keep the face plate and the cutter/hammers of the hand-held tools against the wall surface.

Exposure to arm-hand vibration was present throughout the operation of the hand-held tools. While arm-hand vibration was not quantitatively measured, it was readily apparent that there was exposure that could potentially cause health problems, such as Raynaud's Syndrome. Some whole-body vibration was also present during operation due to the vibration of the wall and associated walking surface in the area.

Heat stress parameters were monitored using a Quest QuestTemp[®]15 Heat Stress Monitor. The wet-bulb globe temperature was used to determine the work/rest regimen in accordance with the American Conference of Governmental Industrial Hygienist (ACGIH) recommendations. The wet-bulb globe temperature was adjusted in accordance with ACGIH guidelines for the type of clothing, including PPE, that the worker was wearing.

While heat stress will be increased when wearing PPE, the overall heat stress response will vary from worker to worker. Each situation in which the technology is used will need to be evaluated for the heat stress potential, taking into consideration the wet-bulb globe temperature, PPE in use, physical condition of the worker, and amount of worker acclimatization.

Dust monitoring was conducted with a sampling train consisting of an SKC IOM Inhalable dust sampler coupled with an MSA Escort Elf air sampling pump. Pre- and post-sampling calibration was accomplished using a BIOS International DryCal DC1 primary calibration system. Sampling filters were desiccated pre- and post-sampling and weighed on an OHAUS Scout Electronic Balance. Sampling was conducted in accordance with NIOSH method 0500.

Personal air sampling was conducted on the equipment operators during the wall decontamination demonstration. Personal dust sampling values of 28.60 mg/m³ and 0.00 mg/m³ were obtained for Operator No. 1 and 30.82 mg/m³ and 0.00 mg/m³ for Operator No. 2. One value for each operator exceeds the Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) and the ACGIH threshold limit value (TLV) of 15 mg/m³ and 10 mg/m³ respectively for total dust. This may be accounted for by large pieces of concrete debris that was visible on the sampling filters on the day when the dust results were elevated. This occurred on the first day of the wall decontamination demonstration. The next day, the sampling results showed no dust accumulation and there was no visible debris on the filters. This may, in part, be attributed to the operators adjusting to using the hand-held tools on the wall surface. This illustrates the importance of worker training to include instructing the worker on developing and using work habits that keep him/her from exposure to hazards.

Additionally, there were larger pieces of debris left on the walking surface. This debris could potentially become airborne and, therefore, become an inhalation hazard. Due to this and the dust sampling being conducted in a semi-open environment, it is recommended that sampling be conducted while the wall decontamination operation is being carried out in a closed environment. A complete air sampling plan for a site would need to be developed to include not only dust but other contaminants specific to the wall decontamination project. (See Appendix B for sampling data.)

Personal noise monitoring was conducted using a Metrosonic db-3100 data logging noise dosimeters. Calibration was conducted pre- and post-monitoring using a Metrosonics CL304 acoustical calibrator. Monitoring was conducted on Operator No. 1 for 3.05 hours (183 minutes) and on Operator No. 2 for 3.33 hours (200 minutes). Monitoring during this time showed a noise dose of 209.54% which gives an 8-hour time weighted average (TWA) of 95.3 dBA for operator number 1. If Operator No. 1 continued to have this same level of noise exposure during the entire 8-hour shift, a projected noise dose would be 548.97% (TWA -102.3 dBA).

Monitoring for Operator No. 2 showed a noise dose of 236.96% (TWA - 96.2 dBA). If Operator No. 2 continued to have this same level of noise exposure during the entire 8-hour shift, a projected noise dose would be 568.24% (TWA -102.5 dBA).

The OSHA allowable PEL for noise is a 100% dose or an 8-hour TWA of 90 dBA. The operators were overexposed after all periods of time. At these exposure levels, personnel would be required to be included in a hearing conservation program. Feasible engineering controls, administrative controls, and personal protective equipment (PPE-hearing protection devices) need to be used. The noise levels produced by the wall decontamination system may require that engineering and administrative controls, as well as hearing protection devices, all be simultaneously employed to control the noise level. The percentage of time spent at each loudness level that comprises the exposures can be seen in Appendix B.

During monitoring, the noise levels were averaged for each one minute period of time, and then an overall average was calculated. An average exposure level of 102.3 dBA was obtained for Operator No. 1 and 102.5 dB for Operator No. 2. The maximum sound level measured for Operator No. 1 was 116.4 dB and 114.7 dB for Operator No. 2. The peak exposure seen for Operator No. 1 was 142.9 dB and for Operator No. 2, 135.8 dB.

These measurements define noise as an extreme exposure hazard for personnel operating the LTC wall decontamination technology. It must also be noted that the equipment was being operated in a semi-open structure at the time of the measurements. Operation in a facility that is fully enclosed will have the potential to increase the noise level due to other influences such as vibration and reverberation.

HUMAN FACTORS INTERFACE

The need to utilize different levels of personal protective equipment, such as Level A, B, C, or D will depend on the contaminants associated with the wall being decontaminated. These contaminants should be identified by the site characterization prior to the start of the wall decontamination job.

The level of protection being utilized has the potential to cause several human factors interface problems. These may include but not be limited to visibility, manual dexterity, tactile sensation, an increase in heat stress, and an overall increase in physical stress.

The amount of arm-hand vibration the operator was receiving during operation of the hand-held tools creates an additional human factors interface issue. It is recommended that further evaluation with quantitative measurements of arm-hand vibration be conducted for this equipment.

- ◆ OSHA 29 CFR 1910.147 The Control of Hazardous Energy (Lockout/Tagout)
- ◆ OSHA 29 CFR 1926.52 Occupational Noise Exposure
- ◆ OSHA 29 CFR 1910.95 Occupational Noise Exposure
- ◆ OSHA 29 CFR 1926.103 Respiratory Protection
- ◆ OSHA 29 CFR 1910.134 Respiratory Protection
- ◆ OSHA 29 CFR 1926.102 Eye and Face Protection
- ◆ OSHA 29 CFR 1910.133 Eye and Face Protection
- ◆ OSHA 29 CFR 1926.28 Personal Protective Equipment
- ◆ OSHA 29 CFR 1910.132 Personal Protective Equipment
- ◆ OSHA 29 CFR 1910.132 General Requirements (Personal Protective Equipment)
- ◆ OSHA 29 CFR 1926.23 First Aid and Medical Attention
- ◆ OSHA 29 CFR 1910.151 Medical Services and First Aid
- ◆ OSHA 29 CFR 1910.1000 Toxic and Hazardous Substances

Best management practices:

- ◆ ANSI S3.34-1986 Guide for the Measurement and Evaluation of Human Exposure to Vibration Transmitted to the Hand
- ◆ ACGIH Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices
- ◆ NIOSH Revised Lifting Equation, 1994

In addition to the above regulations and policies, it is imperative that all workers have appropriate and adequate training for the task and associated safety and health conditions. Training that would be required may be divided into four categories. Core training is that which is required for anyone entering a hazardous waste site to perform work, regardless of the type of job. Technology specific training is that training that is

specific to the technology and required by safety and health standards. Special training is that which is specific to the technology to assure the worker is adequately trained for the task but is not necessarily required by safety and health standards. Best management practices are trainings that while not mandated by health and safety standards, provide information and knowledge to the worker that will allow the worker to perform the job safely. Training to be applied for the LTC PT6-Vacuum System may include but not be limited to:

Core training requirements:

- ◆ HAZWOPER
- ◆ HAZCOM

Technology Specific training:

- ◆ Scaffolding
- ◆ Respiratory Protection
- ◆ Hearing Conservation
- ◆ Personal Protective Equipment
- ◆ Lockout/Tagout

Special training:

- ◆ Job specific training for equipment operation

Best Management Practice training:

- ◆ Ergonomics (proper lifting, bending, stooping, kneeling, arm-hand vibration)
- ◆ Heat stress (learning to recognize signs and symptoms)
- ◆ CPR/First Aid/Emergency Response/Bloodborne Pathogens
- ◆ Electrical Safety
- ◆ Hand Signal Communication
- ◆ Construction Safety (OSHA 500) and or General Industry Safety (OSHA 501)

SECTION 6 - OPERATIONAL CONSIDERATIONS & RECOMMENDATIONS

Recommendations made in this section for improved worker safety and health take into consideration the operation of the hand-held tools with the LTC PTC-6 vacuum system. Specific recommendations include:

- ◆ It needs to be assured that workers are aware of the tripping hazards associated with air and vacuum hoses that are necessary to operate the equipment. Keeping these as orderly as possible in compliance with good housekeeping regulations will help avoid injury due to tripping.
- ◆ The vacuum hoses were not connected to the outlet on the pieces of hand-held tools by means of a clamping system. This could allow the hoses to be pulled loose and create an exposure to the contaminant. Hoses should be attached with some type of clamping system to reduce the possibility that they will become detached accidentally.
- ◆ The operators of the equipment need to have training in ergonomics to assure proper techniques in lifting, bending, stooping, twisting, etc. during equipment operation. In addition, training needs to include discussion on ergonomics associated with the wrists/hands, arms, and shoulders when using hand-held tools. The tools themselves need to be evaluated for ergonomic design to enable the worker to use them without having to place themselves in awkward positions or to place an excessive amount of force against the tool to keep it in contact with the wall. For example, the workers had to place their hands on the housing of the one hand-held tool to move and control it because the handle was not in the best position. A better design to include a movable handle would allow the worker to move it to the required position.
- ◆ If a fitting on an air line fails, the flying hose has the potential to cause severe injury. A safety line connected to the male and female parts of the fitting would keep the hose from becoming a flying object.
- ◆ A full 23-gallon drum may weigh 220 pounds or more and a 55-gallon drum even more. This presents great potential for back injury when two operators lift the drum for change out. It is recommended that the system be evaluated for use with a mechanical lifting system.
- ◆ The cleaning (blow back) of the filters was a manual operation. If this were automated to occur at set intervals of time, the operation would be more efficient and reduce the possibility of worker exposure.

- ◆ Noise exposure was above the PEL during operation of the PTC-6 system. Since testing was done in a semi-open three walled structure, it is plausible that the noise levels would increase in a fully enclosed environment. The equipment needs to be evaluated for possible engineering controls to help decrease the noise exposure to the operator. If engineering controls are not possible, administrative controls, and/or adequate hearing protection must be incorporated during operation.

- ◆ Wall decontamination requires that the worker be able to reach the top and the bottom portions of the walls to decontaminate them. Decontamination of the bottom portion of the wall requires the worker to assume awkward positions such

Figure 2. Worker decontaminating lower portion of the wall using star-cutters.

as stooping, squatting, bending, or kneeling, which also causes contact with the potentially contaminated walking surface. A longer handle on the hand-held tool or an adjustable stool would allow this to be accomplished without having to assume the awkward positions and/or come in contact with the walking surface.

Reaching the top portion of the wall requires the use of scaffolding. Proper precautions must be taken including compliance with the OSHA scaffold regulation, falling object protection, and training. No one should be permitted to work in the area of the scaffolding without a hard hat. The worker on the scaffolding was having to put a large amount of force against the hand-held tool to hold it against the wall. This was accomplished by using his body weight to push against the tool. In addition to ergonomic concerns, this has the potential to move or tip the scaffolding and should be avoided. A better method would be engineering the tool to require less pressure to keep it in contact with the wall, such as appropriately located handles for vertical work. Attaching the scaffolding to the wall would also alleviate this concern.

Figure 3. Worker decontaminating upper portion of wall using star-cutters.

- ◆ It must be noted that a ladder (which was not used during the testing demonstration) would not be appropriate for this type of work. Three-points of contact could not be maintained while using the hand-held tools.

- ◆ Due to the high humidity environment in which the testing demonstration took place, LTC used an air dryer in-line with the system. This is not required for operation but was intended to keep the air lines free of moisture. There was, however, water dripping from the unit. This created a slippery walking surface and had the potential to create a secondary waste problem. Preventative maintenance and assuring all components are in working order is of utmost importance. In addition, a method for catching or containing the dripping water or placing the unit outside of the contaminated area would help with these problems.
- ◆ The star cutters had to be changed frequently. The worker must handle many sharp star-shaped disks. The sharp edges have the potential to cut the worker's gloves which in turn increases the worker's potential for not only being cut, but also being exposed to contaminants. Providing several tool cutter heads with the star cutters already in place would be a better method. This would allow the heads to be changed in the contaminated area and the old cutter head could be decontaminated and removed to the "clean area" to change the star cutters. If the star cutters have to be changed while they are contaminated, gloves to prohibit cutting may need to be worn in addition to gloves for protection against the contaminant.
- ◆ There was visible sparking seen when the star cutter was being used on the concrete wall. This would prohibit this hand-held tool from being used in an explosive atmosphere or around any potential ignition sources.
- ◆ The vacuum hose, which is 1½ - 2 inches in diameter and is attached to the back of the star cutter hand-held tool (which was being used from the scaffolding), added weight to the tool and pulled in a downward direction. This increases ergonomic stressors placed on the worker. Some type of hook on the railing of the scaffolding to support the vacuum hose and keep it from pulling would help with this problem.

Due to the semi-open three walled environment in which the testing demonstration was conducted and, therefore, the dust monitoring was conducted, it is recommended that further testing for dust exposure be conducted while the technology is used in a closed environment similar to environments in which it would be used at a hazardous waste clean-up site. It is also recommended that noise monitoring be conducted while the technology is used inside a fully enclosed environment. This would also allow for an evaluation of the heat stress to be encountered while wearing the appropriate PPE in different environments.

The safety and health issues discussed throughout this report could be reduced and, in some cases, eliminated if this type of wall decontamination technology could operate remotely.

APPENDIX A REFERENCES

**Occupational Safety and Health Standards for General Industry, 29 CFR Part 1910,
Occupational Safety and Health Administration United States Department of Labor**

**Occupational Safety and Health Standards for the Construction Industry, 29 CFR Part
1926, Occupational Safety and Health Administration United States Department of
Labor**

**Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents and
Biological Exposure Indices (BEIs), American Conference of Governmental Industrial
Hygienists, 1995-1996**

**ANSI 1986, Guide for the measurement and evaluation of human exposure to vibration
transmitted to the hand, New York, NY: American National Standards Institute, ANSI
S3.34**

**The NIOSH compendium of hearing protection devices, U.S. Department of Health and
Human Services, Public Health Service, Center for Disease Control and Prevention,
October 1994**

**U.S. Department of Health and Human Services, Applications Manual for the Revised
NIOSH Lifting Equation, January 1994**

APPENDIX B IH SAMPLING DATA

ETC-WHITE DECONTAMINATION SYSTEM Total Dust Sampling			
7/28/97	072897-FIU-002	Blank	0.00 mg/m ³
7/28/97	072897-FIU-004	Total dust	28.60 mg/m ³
7/28/97	072897-FIU-001	Total dust	30.82 mg/m ³
7/29/97	072997-FIU-003	Blank	0.00 mg/m ³
7/29/97	072997-FIU-006	Total dust	0.00 mg/m ³
7/29/97	072997-FIU-005	Total dust	0.00 mg/m ³

- * The OSHA PEL for total dust is 15 mg/m³ and the ACGIH TLV is 10 mg/m³. Current sampling was conducted for total dust. The need to sample for respirable dust and silica has to be considered during concrete decontamination and decommissioning activities.

NOISE SAMPLING

Amplitude Distribution Data

The percentage of time spent at each decibel level can be obtained from the graph. As shown, 2.539% of the time the noise exposure was less than 85dBA which means only 97.461% of the time was spent at sound levels above 85dBA. OSHA requires that a hearing conservation program be initiated if the 8-hour TWA is 85dBA.

NOISE SAMPLING DATA

Amplitude Distribution Data

The percentage of time spent at each decibel level can be obtained from the graph. As shown, 5.509% of the time the noise exposure was less than 85dBA which means only 94.491% of the time was spent at sound levels above 85dBA. OSHA requires that a hearing conservation program be initiated if the 8-hour TWA is 85dBA.

APPENDIX C

ACRONYMS

ACGIH	-	American Conference of Governmental Industrial Hygienists
ANSI	-	American National Standards Institute
DOE	-	Department of Energy
FIU	-	Florida International University
HAZWOPER	-	Hazardous Waste Operations and Emergency Response
HAZCOM	-	Hazard Communication
HEPA	-	high efficiency particulate air filter
NIOSH	-	National Institute of Occupational Safety and Health
NFPA	-	National Fire Prevention Association
OSHA	-	Occupational Safety and Health Administration
PEL	-	permissible exposure limits
PPE	-	personal protective equipment
SOP's	-	standard operating procedures
TLV	-	threshold limit value
TWA	-	time weighted average

PENTEK, INC.
WallWalker™
TABLE OF CONTENTS

ACKNOWLEDGEMENTS.....	iii
EXECUTIVE SUMMARY	iv
SECTION 1 – SUMMARY	1
Technology Description	1
Key Results	2
SECTION 2 - SYSTEM OPERATION.....	2
SECTION 3 - HEALTH AND SAFETY EVALUATION	3
General Health and Safety Concerns	3
Core Issues	4
Best Management Practices.....	5
Industrial Hygiene Monitoring	5
Human Factors Interface	8
Technology Applicability	8
SECTION 4 - JOB SAFETY ANALYSIS (JSA)	9
SECTION 5 - FAILURE MODES AND EFFECTS ANALYSIS (FMEA).....	14
SECTION 6 - TECHNOLOGY SAFETY DATA SHEET (TSDS)	15
SECTION 7 - EMERGENCY RESPONSE/PREPAREDNESS	24
SECTION 8 - REGULATORY POLICY ISSUES.....	24
Core Requirements	24
Technology Specific Requirements	25
Best Management Practices.....	26
Core Training Requirements.....	26
Technology Specific Training.....	26
Special Training	27
Best Management Practice Training.....	27
SECTION 9 - OPERATIONAL CONSIDERATIONS AND RECOMMENDATIONS	27

TABLE OF CONTENTS
(Continued)

APPENDIX A - REFERENCES	32
APPENDIX B - INDUSTRIAL HYGIENE DATA	33
APPENDIX B - ACRONYMS	40

ACKNOWLEDGEMENTS

The human factors assessment of Pentek, Inc. WallWalker™ was conducted under support of the U.S. Department of Energy's Federal Energy Technology Center, under cooperative agreement DE-FC21-95MC32260 with the Operating Engineers National Hazmat Program. The Operating Engineers National Hazmat Program would like to thank the following people for their participation on the "research action team" and the professional expertise they provided for this assessment:

Barbara McCabe
Pat Bell
Lane Parker

Operating Engineers National Hazmat Program
Operating Engineers National Hazmat Program
Operating Engineers Local Union 470

EXECUTIVE SUMMARY

The Pentek, Inc. WallWalker™ consists of a remotely operated, computer controlled positioning system interfaced with a scabblers for the removal of coatings and concrete from vertical surfaces. The integrated WallWalker™ remote positioning/decontamination system consists of a motion control system, scabblers head interface, and a HEPA vacuum system.

The motion control system precisely controls the position, velocity, and acceleration of the scabblers head over the entire vertical plane. This patented system works independently controlling the lengths of two separate cables that hang from the upper left and right sides of the wall. Both cables are joined together at a single point with a yoke and clevis which defines the attachment point of the end effector (scabblers head).

The operator interface consists of a touch control screen for entering the physical/geometric setup parameters and motion profiles. The software (Parasol II) is flexible in accommodating variations in the initial conditions for each of the two reeving motor drive assemblies and their relationship to the wall.

The WallWalker™ scabblers head utilizes a "low-friction" static seal by maintaining a vacuum flow for dust and contamination control, while maximizing the vacuum pressure between the scabblers and the wall.

Vacuum flow is provided via a VAC-PAC® vacuum system which has two stage positive filtration sufficient to support safe and efficient vacuuming of materials. First stage roughing filter efficiency is 95% at 1 micron, with second stage high efficiency particulate air filter efficiency of 99.97% at 0.3 microns.

During the assessment sampling was conducted for dust and noise and general observational techniques were conducted for ergonomics. General observational techniques for ergonomics showed the potential for some ergonomic problems during surface coating removal using the WallWalker™. During setup and tear down there is the potential for sprain/strain to the back, shoulders, arms, and legs from lifting, bending, moving the cart with the scabbling head on it, and attaching the positioning system to the surface to be scabbled. Attaching and removing the reeving motor drive assembly presents particular concerns for ergonomic stressors in these areas.

Area dust sampling was conducted for total dust during operation of the WallWalker™. There were three operators and they changed out of the work area throughout the testing demonstration. Therefore, area sampling was conducted at the operator's work station to determine the potential exposures over a longer period of time. All dust sampling conducted in the area of the operator's station showed results below the OSHA PEL and the ACGIH TLV of 15 mg/m³ and 10 mg/m³ respectively for total dust. Sampling values shown

were 0.00 mg/m³ and 0.00 mg/m³. All dust sampling conducted at the scabbling head showed results in excess of the OSHA PEL and ACGIH TLV. Sampling values shown were 64.9 mg/m³, 46.7 mg/m³, and 106.5 mg/m³. All of the samples showing elevated levels also had visible grit and larger pieces of concrete on the sampling filters. This may in part explain these higher results.

Area noise measurements were taken at the operator's station and in the area of the ancillary equipment. Noise measurements at the operator's station showed noise doses of 20.51% which gives an 8-hour time weighted average (TWA) of 78.7 dBA, 100.62% (TWA – 90 dBA), 124.90% (TWA – 91.6 dBA), and 128.20% (TWA – 91.8 dBA). Noise measurements at the ancillary equipment showed noise doses of 61.7% (TWA – 87.5 dBA) and 118.88% (TWA – 91.2 dBA).

The OSHA allowable PEL for noise is a 100% dose or an 8-hour TWA of 90 dBA. The above noise doses and TWA's show noise to be a potential exposure hazard for the operator of the WallWalkerTM and ancillary equipment. While the operator's distance from the WallWalkerTM and the amount of time spent in the area where the scabbling is taking place can affect the operator's exposure level, the majority of the TWA's during the testing demonstration were at a level where the operator would be required to be included in a hearing conservation program. Feasible engineering controls, administrative controls, and personal protective equipment (hearing protection devices) need to be used as appropriate.

Recommendations for improved worker safety and health during use of the WallWalkerTM include: 1. keeping all hoses and lines as orderly as possible in compliance with good housekeeping requirements; 2. ergonomic training to include techniques in lifting, bending, stooping, twisting, etc.; 3. a safety fitting on airlines; 4. GFCI and appropriate grounding on all electrical connections; 5. an evaluation of the capture velocity of the vacuum system; 6. an evaluation of engineering controls for noise exposure; 7. require the operator to always be in attendance at the control panel; 8. label the control screen at the control panel "touch screen"; 9. and design an interlock so the WallWalkerTM will not continue to operate if the plastic caps on the access holes in the back of the scabbling head are removed.

PENTEK, INC.
WALLWALKER™
HUMAN FACTORS ASSESSMENT

SECTION 1 - SUMMARY

TECHNOLOGY DESCRIPTION

The Pentek, Inc. WallWalker™ technology was tested and is being evaluated at Florida International University (FIU) as a baseline technology. In conjunction with FIU's evaluation of efficiency and cost, this report covers the hazard analysis and safety evaluation.

The WallWalker™ consists of a remotely operated, computer controlled positioning system interfaced with a scabbler for the removal of coatings and concrete from vertical surfaces. The integrated WallWalker™ remote positioning/decontamination system consists of a motion control system, scabbler head interface, and a HEPA vacuum system.

The motion control system precisely controls the position, velocity, and acceleration of the scabbler head over the entire vertical plane. This patented system works independently, controlling the lengths of two separate cables that hang from the upper left and right sides of the wall. Both cables are joined together at a single point with a yoke and clevis which defines the attachment point of the end effector (scabbler head).

The operator interface consists of a touch control screen for entering the physical/geometric setup parameters and motion profiles. The software (Parasol II) is flexible in accommodating variations in the initial conditions for each of the two reeving motor drive assemblies and their relationship to the wall.

The WallWalker™ scabbler head utilizes a "low-friction" static seal by maintaining a vacuum flow for dust and contamination control, while maximizing the vacuum pressure between the scabbler and the wall.

Vacuum flow is provided via a VAC-PAC® vacuum system which has two stage positive filtration sufficient to support safe and efficient vacuuming of materials. First stage roughing filter efficiency is 95% at 1 micron, with second stage high efficiency particulate air (HEPA) filter efficiency of 99.97% at 0.3 microns.

KEY RESULTS

The safety and health evaluation during the testing demonstration focused on two main areas of exposure: dust and noise. Dust and noise exposure was potentially significant. Several of the air samples taken for total dust were in excess of the Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) of 15 mg/m^3 and the American Conference of Industrial Hygienists (ACGIH) threshold limit value (TLV) of 10 mg/m^3 but grit and/or larger pieces of concrete were visible on the air sampling filter for these samples. Noise monitoring showed levels in excess of the OSHA action level of 85 dBA but only a couple of sampling periods showed noise levels above the PEL of 90 dBA. This and the potential for dust exposure will be discussed in greater detail in the Industrial Hygiene section of this report. Other safety and health hazards found were ergonomics, heat stress, tripping hazards, electrical hazards, machine guarding, and lockout/tagout.

SECTION 2 - SYSTEM OPERATION

The Pentek WallWalker™ consists of a remotely operated, computer controlled positioning system interfaced with a scabbler for the removal of coatings and concrete from vertical surfaces. The integrated WallWalker™ remote positioning/decontamination system consists of a motion control system, scabbler head interface, and a HEPA vacuum system.

The motion control system precisely controls the position, velocity, and acceleration of the scabbler head over the entire vertical plane. This patented system works independently controlling the lengths of two separate cables that hang from the upper left and right sides of the wall. Both cables are joined together at a single point with a yoke and clevis which defines the attachment point of the end effector (scabbler head).

Figure 1. WallWalker™ suspended from "quasi-infinite" cable.

The length of each cable is controlled by a DC brushless servo motor that is attached to a cable reeving device. The once through device is unique in its ability to use "quasi-infinite" cable lengths so the system can be used on extremely large surface areas. The absolute accuracy of cable length adjustment is to within 0.01 inches. Constant velocity is user defined up to 60 feet per minute. The two reeving motor drive assemblies can be attached directly to the wall by mechanical methods such as bolting, clamping, vacuum suction or magnetics. They can also be attached to a

"false" compression beam and suspended above the wall.

The operator interface consists of a touch control screen for entering the physical/geometric setup parameters and motion profiles. The software (Parasol II) is flexible in accommodating variations in the initial conditions for each of the two reeving motor drive assemblies and their relationship to the wall. Several of the basic motion profiles include straight line, raster pattern, circle, and alpha-numeric characters.

The WallWalker™ scabblers head utilizes a "low-friction" static seal by maintaining a vacuum flow for dust and contamination control, while maximizing the vacuum pressure between the scabblers and the wall.

Inside the scabbling head is a triangular array of three pneumatically operated scabblers. Each scabblers is mounted on an independent suspension to allow for variations in surface height and to maintain optimum cutting force against the wall. The array of three scabblers is rotated about the assembly's central axis during scabbling to maintain a uniformly keyed, even surface profile as the assembly transverses across the wall at a constant velocity. The depth of concrete removal in a single pass can be regulated from 1/16 to 1/4-inch by controlling the velocity of the scabblers head over the surface. Greater depth of removal can be achieved with multiple passes.

Vacuum flow is provided via a VAC-PAC® vacuum system which has two stage positive filtration sufficient to support safe and efficient vacuuming of materials. First stage roughing filter efficiency is 95% at 1 micron, with second stage HEPA efficiency of 99.97% at 0.3 microns. The VAC-PAC® design is Pentek's exclusive controlled seal drum fill system, which allows the operator to fill, seal, remove, and replace the waste drum under controlled vacuum conditions. This assures positive control of waste and dust and minimizes the possibility of releasing airborne contamination during drum changing operations.

Figure 2. VAC-PAC® vacuum system.

SECTION 3 - HEALTH AND SAFETY EVALUATION

GENERAL SAFETY AND HEALTH CONCERNS

Personnel where the WallWalker™ scabbling technology is being used need to be concerned with safety and health issues. Issues that personnel need to be cognizant of may be divided into two categories. Core issues are those that are based on current safety and health regulatory requirements. Best management practices are related to issues that are not based on current safety and health regulations, but are key elements in preventing worker injury and illness on the job.

Safety and health issues of concern with the WallWalker™ scabbling technology included:

Core Issues:

- ◆ Housekeeping - The air lines, electrical lines, vacuum hoses, and computer lines are necessary for system operation but are tripping hazards. Stringent housekeeping must be addressed.
- ◆ Electrical hazards - The electric cords necessary to operate the equipment may present electrical hazards and the need for ground fault circuit interrupters (GFCI) and grounding must be evaluated.
- ◆ Lockout/Tagout - Before any maintenance or decontamination activities are conducted hazardous energy sources need to be eliminated. A lockout/tagout program will need to be developed.
- ◆ Pinch points - The potential exists for the operator to have his/her fingers/hands crushed during maintenance/repair if the scabblers were to be activated during this time. The back of the scabbling head has openings that can be accessed during operation. These areas need to be labeled as pinch points. The head needs to be evaluated for interlocks on the covers for these areas.
- ◆ Fall hazard - Installation of the WallWalker™ to the surface to be scabbled requires workers to work from a ladder, scaffolding, or elevated platform. This presents the potential for fall hazards. Fall protection may be required. If scaffolding is being used, compliance with the OSHA scaffold standard must be assured.
- ◆ Noise - Noise levels were found to be above the OSHA action limit with potential for exposure above the PEL. This will be discussed in greater detail in the Industrial Hygiene section of this report.
- ◆ Dust - Some visible dust was seen at the blast head when the seal with the wall was disrupted. Several of the air samples taken for total dust were in excess of the OSHA PEL of 15 mg/m³ and the ACGIH TLV of 10 mg/m³ but grit and/or larger pieces of concrete were visible on the air sampling filter for these samples. This will be discussed in greater detail in the Industrial Hygiene section of this report.

Best management practices:

- ◆ Diesel exhaust - Operation of the WallWalker™ requires an air compressor. If a diesel generated air compressor is used the potential exists for exposure to diesel exhaust. Diesel should not be exhausted indoors or where the exhaust can be pulled into an air intake.
- ◆ Heat stress - Workers are subjected to an increase in heat stress due to the need to utilize personal protective equipment (PPE). The user will need to develop a heat stress program for the environment in which the scabber is being used, taking into consideration any PPE that may need to be utilized, ambient temperatures, etc.
- ◆ Ergonomics - There are ergonomic stressors associated with the use of the WallWalker™, in particular during setup and tear down. There is potential for stress/strain to the back, shoulders, arms, and legs.
- ◆ Communication - Due to the noise generated by the technology during operation, communication may be difficult. Personnel working in the area need to be familiar with hand signals and use them as appropriate.
- ◆ Fall from above hazards - There is the potential for items to be dropped by personnel working at an elevation to attach the WallWalker™ to the surface to be scabbled. Anyone working on the ground in this area needs to be wearing a hard hat.

INDUSTRIAL HYGIENE MONITORING

During this testing demonstration with the WallWalker™, sampling was conducted for dust and noise. In addition, the wet-bulb globe temperature was monitored to evaluate heat stress and observational evaluation was conducted for ergonomics.

Through general observational techniques the potential for ergonomic stressors was evaluated during the testing demonstration. During setup and tear down there is the potential for sprain/strain to the back, shoulders, arms, and legs from lifting, bending, moving the cart with the scabbling head on it, and attaching the positioning system to the surface to be scabbled.

Attaching the positioning system to the vertical surface requires the worker to lift the reeving motor drive assembly above the head, hold it in place, and anchor it with bolts. The assembly weighs approximately 50 pounds. This places a great deal of stress on the back, shoulders, neck, and arms. A mechanical lift for hoisting and holding the assembly in place while it is attached or using a scissor lift and having two workers attach the assembly would help to alleviate many of these stressors. Additionally, using

a ladder while anchoring the assembly does not allow the worker to maintain three points of contact while on the ladder. Therefore, a ladder should not be used for this purpose.

Moving the cart with the scabbling head on it has the potential for sprain/strain (from bending to push the cart) to the back, shoulders, and arms. The scabbling head weighs approximately 450 pounds. Using a cart that is adjustable in height so the worker will not have to bend and having a handle on the cart to push or pull instead of pushing/pulling on the cart itself, will help to lessen the stress placed on the back. Using a mechanical means, such as a fork lift or a powered cart, would eliminate the need for the worker to push/pull the cart and therefore, eliminate the ergonomic stressors.

Heat stress parameters were monitored using a Quest QuestTemp[®]15 Heat Stress Monitor. The wet-bulb globe temperature was used to determine the work/rest regimen in accordance with ACGIH recommendations. The wet-bulb globe temperature was adjusted for the type of clothing, including PPE, in accordance with ACGIH recommendations. While heat stress will be increased when wearing PPE, the overall heat stress response will vary from worker to worker. Each situation in which the current technology is used will need to be evaluated for the heat stress potential, taking into consideration the wet-bulb globe temperature, PPE in use, physical condition of the worker, and amount of worker acclimatization.

Dust monitoring was conducted with a sampling train consisting of an SKC IOM Inhalable dust sampler coupled with an MSA Escort Elf air sampling pump. Pre- and post-sampling calibration was accomplished using a BIOS International DryCal DC1 primary calibration system. Sampling filters were desiccated pre- and post-sampling and weighed on an OHAUS Scout Electronic Balance. Sampling was conducted in accordance with National Institute of Occupational Safety and Health (NIOSH) method 0500.

Area dust sampling was conducted for total dust during operation of the WallWalker[™]. There were three operators and they changed out of the work area throughout the testing demonstration. Therefore, area sampling was conducted at the operator's work station to determine the potential exposures over a longer period of time. All dust sampling conducted in the area of the operators station showed results below OSHA PEL and ACGIH TLV of 15 mg/m³ and 10 mg/m³ respectively. Sampling values shown were 0.0 mg/m³ and 0.0 mg/m³. All dust sampling conducted at the scabbling head showed results in excess of the OSHA PEL and ACGIH TLV. Sampling values shown were 64.9 mg/m³, 46.7 mg/m³, and 106.5 mg/m³. All of the samples showing these elevated levels also had visible grit and larger pieces of concrete on the sampling filters. This may in part explain these higher results.

Area noise monitoring was conducted during the operation of the blaster. As with dust sampling, since the operators were changing every 20-30 minutes, area monitoring was

conducted to determine the potential for exposure to noise over a longer period of time. Noise monitoring was conducted using Metrosonic db-3100 data logging noise dosimeters. Calibration was conducted pre- and post-monitoring using a Metrosonics CL304 acoustical calibrator.

Area noise measurements were taken at the operators station and in the area of ancillary equipment such as the VAC-PAC®. Area noise measurements at the operators station were taken for 2.55 hours (153 minutes), 8.21 hours (493 minutes), 7.18 hours (431 minutes), and 7.2 hours (434 minutes). This gives an 8-hour noise dose of 20.51% which gives an 8-hour time-weighted average (TWA) of 78.7 dBA, 100.62% (TWA-90.0 dBA), 124.90% (TWA-91.6 dBA), and 128.20% (TWA-91.8 dBA). If these noise levels were the same over an 8-hour period, projected noise doses would be 64.12% (TWA-86.9 dBA), greater than 100% (TWA-greater than 90.0 dBA), 138.91% (TWA-92.4 dBA), and 141.77% (TWA-92.5 dBA). During these time periods the noise levels were averaged for each one-minute period of time. An overall average was calculated yielding an average exposure level of 86.9 dB, 89.9 dB, 92.4 dB, and 92.5 dB. The maximum sound levels during the sampling periods were 116.0 dB, 96.6 dB, 100.8 dB, and 99.6 dB. The highest instantaneous sound pressure levels were greater than 140.0 dB, 123.6 dB, 121.9 dB, and 133.7 dB. The amount of time spent at each loudness level that comprises the exposures can be seen in Appendix B.

Area noise measurements at the ancillary equipment were taken for 6.95 hours (417 minutes) and 8.45 hours (507 minutes). This gives an 8-hour noise dose of 61.7% (TWA of 87.5 dBA) and 118.88% (TWA-91.2 dBA). If these noise levels were the same over an 8-hour period, projected noise doses would be 70.24% (TWA-87.5 dBA), greater than 100% (TWA-greater than 90.0 dBA). During these time periods the noise levels were averaged for each one-minute period of time. An overall average was calculated yielding an average exposure level of 87.5 dB and 90.7 dB. The maximum sound levels during the sampling periods were 96.3 dB and 112.0 dB. The highest instantaneous sound pressure levels were 126.2 dB and greater than 140.0 dB. The amount of time spent at each loudness level that comprises the exposures can be seen in Appendix B.

The OSHA allowable PEL for noise is a 100% dose or an 8-hour TWA of 90 dBA. The above noise doses and TWA's show noise to be a potential exposure hazard for the operator of the WallWalker™ and ancillary equipment. While the operator's noise dose is dependent on his/her distance from the WallWalker™ and amount of time spent in the area where the scabbling is taking place, the majority of the TWA's are at a level where the operator would be required to be included in a hearing conservation program. Feasible engineering controls, administrative controls, and personal protective equipment (PPE-hearing protection devices) need to be used as appropriate.

HUMAN FACTORS INTERFACE

The need to utilize different levels of PPE, such as Level A, B, C, or D will depend on the contaminants associated with the surface being decontaminated and the amount of dust being generated. Contaminants should be identified by the site characterization prior to the start of the decontamination job. The amount of dust being generated will be identified by air sampling conducted during operation of the WallWalker™.

The level of protection being utilized has the potential to cause several human factors interface problems. These may include but not be limited to a decrease in visibility, manual dexterity, and tactile sensation; an increase in heat stress; and an overall increase in physical stress.

TECHNOLOGY APPLICABILITY

The technology produced some visible dust when the seal with the wall was disrupted during operation. Dust samples taken at the operator's station were below the OSHA PEL and the ACGIH TLV. Dust samples taken at the scabbling head were above the OSHA PEL and ACGIH TLV but contained grit and larger pieces of concrete. Noise monitoring indicated that workers are likely be overexposed in accordance with the OSHA PEL and the ACGIH TLV after an 8-hour work shift.

The WallWalker™ will need to be disassembled to be decontaminated. This will not necessarily guarantee that the equipment will be "clean". Parts of the system may need to be considered consumables.

SECTION 4 - JOB SAFETY ANALYSIS

JOB SAFETY ANALYSIS PENTEK, INC. WallWalker™

HAZARD	CORRECTIVE ACTION
UNLOADING/EQUIPMENT/SETUP LOADING/EQUIPMENT/TEAR-DOWN	
* Pinch Points	<ul style="list-style-type: none"> * Use of hand protection * Use proper hand tools for the job * Instruct workers not to ever place hand or finger inside blast pot to assure media flow, through training and standard operating procedures (SOP's)
* Slips/Trips/Falls	<ul style="list-style-type: none"> * Awareness of the specific hazards * Organization of materials (housekeeping) * Walking around areas that are congested/slippery when possible * Walking around tripping hazards when possible * Marking, isolating, or bunching tripping hazards such as vacuum hoses
* Struck-by/Caught between	<ul style="list-style-type: none"> * Awareness of where equipment is being moved at all times * Prohibit worker from being between moving and stationary objects at all times * Keep personnel clear of moving objects
* Muscular/back injury from setting up equipment	<ul style="list-style-type: none"> * Ergonomic training to include safe lifting techniques * Use of equipment such as forklift or crane for unloading * Use mechanical lift for hoisting and holding the assembly in place while it is attached or using a scissor lift and have two workers attach the assembly

* Electrical hazards	<ul style="list-style-type: none"> * Inspect all cords before using * Assure grounding of all equipment, assure use of ground fault circuit interrupters (GFI)
OPERATION OF THE WALLWALKER	
* Struck-by hazard from air line	<ul style="list-style-type: none"> * Inspect all air lines and secure with safety pin before operation * Use safety line (in addition to pin) between male and female ends of connections
* Electrical hazards	<ul style="list-style-type: none"> * Inspect all cords before using * Assure grounding of all equipment, assure use of GFI
* Exposure to noise	<ul style="list-style-type: none"> * Assess WallWalkerTM for feasible engineering controls * Use administrative controls * Use of proper hearing protection device * Worker included in a hearing conservation program
* Exposure to contaminant	<ul style="list-style-type: none"> * Evaluation of system for engineering controls * Use of proper PPE, including respiratory protection
* Pinch points (opening in back of scabbling head)	<ul style="list-style-type: none"> * Label area as pinch hazard, do not remove cover during operation * Engineering design for interlock that shuts down system if covers (for holes) are removed during operation
* Slips/Trips/Falls	<ul style="list-style-type: none"> * Awareness of specific hazards * Organization of materials (housekeeping) * Walking around areas that are congested/slippery when possible * Walking around tripping hazards when possible * Marking, isolating, bunching tripping hazards such as vacuum hoses

CHANGING WASTE DRUM (FROM VAC-PAC®)	
* Back injury/strain/sprain from lifting/moving waste drum	<ul style="list-style-type: none"> * Ergonomic training to include proper lifting techniques * Use a mechanical method to lift/move the drum of waste
* Exposure to Spill of Contaminants	<ul style="list-style-type: none"> * Secure lid on drum before moving * Do not overfill drum * Assure drum filled evenly
* Slips/Trips/Falls	<ul style="list-style-type: none"> * Awareness of specific hazards * Organization of materials (housekeeping) * Walking around areas that are congested/slippery when possible * Walking around tripping hazards when possible
* Pinch Points	<ul style="list-style-type: none"> * Use hand protection * Use of hand tools appropriate for the job
* Accidental Activation	* Use proper lockout/tagout procedures
CHANGING ROUGH FILTER (IN VAC-PAC®)	
* Exposure to/Spill of contaminants	<ul style="list-style-type: none"> * Use of stronger material (than trash bag) for changing filter * Use of gloves while changing filters * Hook bag to unit instead of taping
* Accidental Activation of Unit	* Use proper lockout/tagout techniques
MAINTENANCE	
* Exposure to contaminants	* Use appropriate PPE, including respiratory protection
* Injury from accidental activation of moving parts	* Assure appropriate lockout/tagout program is used before any maintenance is conducted
* Pinch Points	<ul style="list-style-type: none"> * Use of hand protection * Use of hand-held tools appropriate for the job * Use of appropriate lockout/tagout procedures

* Slips/Trips/Falls	<ul style="list-style-type: none"> * Awareness of the specific hazards * Organization of materials (housekeeping) * Walking around areas that are congested/slippery when possible * Walking around tripping hazards when possible
* Ergonomics stressors	<ul style="list-style-type: none"> * Limit duration of work * Use proper lifting techniques * Ergonomic training to include proper lifting techniques
DECONTAMINATION OF SYSTEM	
* Exposure to contaminants	* Use appropriate PPE, including respiratory protection
* Injury from accidental activation of moving parts	* Assure appropriate lockout/tagout program is used before any decontamination activities are conducted
* Pinch Points	<ul style="list-style-type: none"> * Use of hand protection * Use of hand-held tools appropriate for the job * Use of appropriate lockout/tagout procedures
* Slips/Trips/Falls	<ul style="list-style-type: none"> * Awareness of the specific hazards * Organization of materials (housekeeping) * Walking around areas that are congested/slippery when possible * Walking around tripping hazards when possible * Marking, isolating, bunching together tripping hazards such as vacuum hoses
* Ergonomics stressors	<ul style="list-style-type: none"> * Limit duration of work * Use proper lifting techniques * Ergonomic training to include proper lifting techniques

LOADING/TEAR DOWN	
* Pinch Points	<ul style="list-style-type: none"> * Use of hand protection * Use of hand-held tools appropriate for the job
* Slips/Trips/Falls	<ul style="list-style-type: none"> * Awareness of the specific hazards * Organization of materials (housekeeping) * Walking around areas that are congested/slippery when possible * Walking around tripping hazards when possible
* Struck-by/Caught between	<ul style="list-style-type: none"> * Awareness of where equipment is being moved at all times * Prohibit worker from being between moving and stationary objects at all times * Keep personnel clear of moving objects
* Muscular/back injury from taking down equipment	<ul style="list-style-type: none"> * Ergonomic training to include safe lifting techniques * Use of equipment such as forklift or crane for loading * Use mechanical lift for holding the assembly while it is detached from the scabbled surface and for lowering it or using a scissor lift and have two worker detach the assembly

SECTION 5 - FAILURE MODE AND EFFECTS ANALYSIS

FAILURE MODE AND EFFECTS ANALYSIS PENTEK, INC. WALLWALKER™

* Air line ruptures or disconnects	* Injury to worker from being struck by air line
* Safety pin on air line breaks	* Injury to worker from being struck by air line
* Lose vacuum pressure	* Potential for higher concentration of contaminant to be released into air
* Lose vacuum pressure (while changing full drum)	* Potential for exposure to contaminants due to losing seal on barrier placed between drum and filter area
* Vacuum lines comes loose	* Potential for higher concentration of contaminant to be released into atmosphere
* Vacuum line is punctured/ruptured	* Potential for higher concentration of contaminant to be released into atmosphere
* Improper grounding of electrical components	* Reduced capture efficiency
* Lose Power	* Equipment shuts down with potential to momentarily release higher concentration of contaminant into atmosphere
	* Scabbling head releases and goes to ground level with potential to strike worker, if in the area
* Lose seal with wall (lose vacuum or seal broken by rough area in wall)	* Dust (contaminant) releases into the atmosphere with potential for worker exposure
* Bag fails when changing out roughing filters	* Potential for exposure to contaminate

SECTION 6 - TECHNOLOGY SAFETY DATA SHEET

TECHNOLOGY SAFETY DATA SHEET PENTEK, INC. WallWalker™

SECTION 1: TECHNOLOGY IDENTITY	
Manufacturer's Name and Address: PENTEK, Inc. 1026 Fourth Avenue Corapolis, PA 15108-1659	Emergency Contact: (412) 262-0725
	Information Contact: (412) 262-0725
	Date Prepared:
Other Names: WallWalker™	Signature of Preparer: Operating Engineers National Hazmat Program 1293 Airport Road, Beaver, WV 25813 phone 304-253-8674, fax 304-253-7758 Under cooperative agreement DE-FC21-95 MC 32260

SECTION 2: PROCESS DESCRIPTION

The Pentek WallWalker™ consists of a remotely operated, computer controlled positioning system interfaced with a scabber for the removal of coatings and concrete from vertical surfaces. The integrated WallWalker™ remote positioning/decontamination system consists of a motion control system, scabber head interface, and a HEPA vacuum system.

The motion control system precisely controls the position, velocity, and acceleration of the scabber head over the entire vertical plane. This patented system works independently controlling the lengths of two separate cables that hang from the upper left and right sides of the wall. Both cables are joined together at a single point with a yoke and clevis which defines the attachment point of the end effector (scabber head).

The length of each cable is controlled by a DC brushless servo motor that is attached to a cable reeving device. The once through device is unique in its ability to use "quasi-infinite" cable lengths so the system can be used on extremely large surface areas. The absolute accuracy of cable length adjustment is to within 0.01 inches. Constant velocity is user defined up to 60 feet per minute. The two reeving motor drive assemblies can either be attached directly to the wall by mechanical methods such as bolting, clamping, vacuum suction or magnetics; they can also be attached to a "false" compression beam and suspended above the wall.

The operator interface consists of a touch control screen for entering the physical/geometric setup parameters and motion profiles. The software (Parasol II) is flexible in accommodating variations in the initial conditions for each of the two reeving motor drive assemblies and their relationship to the wall. Several of the basic motion profiles include straight line, raster pattern, circle, and alpha-numeric characters.

The WallWalker™ scabber head utilizes a "low-friction" static seal by maintaining a vacuum flow for dust and contamination control, while maximizing the vacuum pressure between the scabber and the wall.

Inside the scabbling head is a triangular array of three pneumatically operated scabblers. Each scabber is mounted on an independent suspension to allow for variations in surface height and to maintain optimum cutting force against the wall. The array of three scabblers is rotated about the assembly's central axis during scabbling to maintain a uniformly keyed, even surface profile as the assembly transverses across the wall at a constant velocity. The depth of concrete removal in

SECTION 2: PROCESS DESCRIPTION

a single pass can be regulated from 1/16 to 1/4-inch by controlling the velocity of the scabbler head over the surface. Greater depth of removal can be achieved with multiple passes.

Vacuum flow is provided via a VAC-PAC[®] vacuum system which has two stage positive filtration sufficient to support safe and efficient vacuuming of materials. First stage roughing filter efficiency is 95% at 1 micron, with second stage HEPA efficiency of 99.97% at 0.3 microns. The VAC-PAC[®] design is Pentek's exclusive controlled seal drum fill system, which allows the operator to fill, seal, remove, and replace the waste drum under controlled vacuum conditions. This assures positive control of waste and dust, and minimizes the possibility of releasing airborne contamination during drum changing operations.

SECTION 3: PROCESS DIAGRAMS

Figure 1. Wall Walker™ suspended from "quasi-infinite" cable.

Figure 2. VAC-PAC® vacuum system.

SECTION 4: CONTAMINANTS AND MEDIA

The technology has the potential to cause concrete dust and associated contaminants to become airborne. These will need to be identified by the site characterization prior to the beginning of the job. A monitoring plan will need to be developed on a site-by-site job-by-job basis.

SECTION 5: ASSOCIATED SAFETY HAZARDS

Probability of Occurrence of Hazard:

- 1 Hazard may be present but not expected over background level
- 2 Some level of hazard above background level known to be present
- 3 High hazard potential
- 4 Potential for imminent danger to life and health

A. ELECTRICAL (LOCKOUT/TAGOUT) RISK RATING: 3

The technology has the potential to present electrical hazards. Assure proper grounding and the use of ground fault circuit interrupters on all equipment. Compliance with applicable electrical standards and codes and lockout/tagout procedures must be followed to assure the safety of personnel.

B. FIRE AND EXPLOSION RISK RATING: 1

Normal fire and explosion hazards in association with electrical powered equipment. The equipment is not intrinsically safe and could not be used in a potentially explosive atmosphere. Additionally, sparking may result from the scabbling process.

C. CONFINED SPACE ENTRY RISK RATING: N/A

Not part of this technology.

D. MECHANICAL HAZARDS RISK RATING: 3

The WallWalker™ has moving parts which may cause injury from pinch points. The areas on the back of the scabber for access to the scabbling head, while covered by plastic caps, are of particular concern. The area needs to be guarded and labeled as a potential hazard.

E. PRESSURE HAZARDS RISK RATING: N/A

Not part of this technology.

F. TRIPPING AND FALLING RISK RATING: 3

The air lines, electrical lines, vacuum hoses, and computer lines present tripping hazards in the area where they are being used.

G. LADDERS AND PLATFORMS	RISK RATING: 3
When attaching the system to the wall, it is necessary to work at a height. This presents the potential for an object falling from above to injure workers at ground level. Proper precautions must be taken. Additionally, proper scaffolding and/or elevated work platform safety must be used.	
H. MOVING VEHICLES	RISK RATING: 3
The presence of multiple pieces of mobile equipment (which may be needed to unload and load the technology) in relationship to a small area of operation may pose a significant danger. Sufficient warning devices such as horns, bells, lights, and back up alarms should be utilized. Personnel should be trained to work with and around moving equipment.	
I. BURIED UTILITIES, DRUMS, AND TANKS	RISK RATING: N/A
Not part of this technology.	
J. PROTRUDING OBJECTS	RISK RATING: N/A
Not part of this technology.	
K. GAS CYLINDERS	RISK RATING: N/A
Not part of this technology.	
L. TRENCHING AND EXCAVATIONS	RISK RATING: N/A
Not part of this technology.	
M. OVERHEAD LIFTS	RISK RATING: 3
Unloading and loading of technology may require overhead lifts or the use of a forklift. Proper precautions indicated.	
N. OVERHEAD HAZARDS	RISK RATING: 2
Would only be present if a crane or forklift were required to unload or load equipment.	

SECTION 6: ASSOCIATED HEALTH HAZARDS	
A. INHALATION HAZARD	RISK RATING: 3
Technology has the potential to produce dust from the material the wall is constructed of, the coating, and related wall contamination. Specific hazards will be identified from the site characterization. Evaluation of total dust and/or respirable dust generated should be conducted.	
B. SKIN ABSORPTION	RISK RATING: 1
This would be dependent on the contaminants at the site and would be identified by the site characterization.	

C. HEAT STRESS	RISK RATING: 3
The need to wear PPE inside the work area has the potential to increase the heat stress placed on the worker. Ambient conditions correlated with PPE, work rates, etc. must be considered.	
D. NOISE	RISK RATING: 4
Noise exposure is a potential exposure hazard during the operation of the WallWalker™. Noise monitoring has shown values in excess of the OSHA PEL and ACGIH TLV for an 8-hour work shift. In addition to feasible engineering controls, administrative controls and adequate hearing protection must be incorporated, as appropriate, during operation.	
E. NON-IONIZING RADIATION	RISK RATING: N/A
Not part of this technology.	
F. IONIZING RADIATION	RISK RATING: N/A
Not part of this technology.	
G. COLD STRESS	RISK RATING: 1
Technology does not produce a hazard, but ambient conditions need to be considered.	

H. ERGONOMIC HAZARDS	RISK RATING: 4
<p>During setup and tear down there is the potential for sprain/strain to the back, shoulders, arms, and legs from lifting, bending, moving the cart with the scabbling head on it, and attaching the positioning system to the surface to be scabbled.</p> <p>Attaching the positioning system to the vertical surface requires the worker to lift the reeving motor drive assembly above the head, hold it in place, anchor it with bolts. The assembly weights approximately 50 pounds. This places a great deal of stress on the back, shoulders, neck, and arms.</p> <p>Moving the cart with the scabbling head on it has the potential for sprain/strain, to the back; shoulders; and arms from bending to push the cart. The scabbling head weights approximately 450 pounds.</p>	
I. OTHER	RISK RATING:
None noted.	

SECTION 7: PHASE ANALYSIS

A. CONSTRUCTION/START-UP

The set-up/start-up phase presents several hazards including struck-by/caught between hazards, pinch points, slips/trips/falls, muscular/back injury, and electrical hazards.

B. OPERATION

The operational phase presents several hazards including exposure to contaminant, noise hazards, hazards associated with the air lines, muscular/back injury, electrical hazards, fall from above hazards, and pinch points.

C. MAINTENANCE

The maintenance phase presents several hazards including pinch points, slips/trips/falls, struck-by/caught between, muscular/back injury, electrical hazards, exposure to contaminants, and accidental activation of moving parts.

D. DECOMMISSIONING

The decommissioning phase presents several hazards including exposure to the contaminants, pinch points, slips/trips/falls, and muscular/back injury.

SECTION 8: HEALTH AND SAFETY PLAN REQUIRED ELEMENTS

A. AIR MONITORING

Operation of the WallWalker™ has the potential to generate dust. An air monitoring plan will need to be developed for total and respirable dust, contaminants of the coating being removed, and contaminants and constituents of the subsurface.

Noise generated during operation of the WallWalker™ is an exposure hazard. A noise monitoring plan is essential.

B. WORKER TRAINING

Training that would apply in this case may include but not be limited to: HAZWOPER (Hazardous Waste Operations and Emergency Response), HAZCOM (Hazard Communication), Respiratory Protection, Hearing Conservation, Ergonomics (proper lifting, bending, stooping, kneeling), Heat Stress (learning to recognize signs and symptoms), Personal Protective Equipment, Emergency Response /Bloodborne Pathogens, Lockout/Tagout, Hand Signal Communication, Construction Safety (OSHA 500), and/or General Industry Safety (OSHA 501). Scaffolding/elevated platform safety is required, as appropriate.

C. EMERGENCY RESPONSE

Emergency response planning for a site needs to assure adequate coverage for hazards described in the TSDS. Having at least one worker per shift trained in CPR and first aid is recommended.

D. MEDICAL SURVEILLANCE

Evaluation of personnel's general health with emphasis on the back and cardiovascular/respiratory system. Medical surveillance as required by the OSHA standards must be conducted. Initial and annual audiograms.

E. INFORMATIONAL PROGRAM

Workers must be trained in specific operation of equipment before use.

SECTION 9: COMMENTS AND SPECIAL CONSIDERATIONS

Only personnel who have been adequately trained in the operation of the WallWalker™ as well as associated hazards should be permitted to operate the system.

SECTION 7 - EMERGENCY RESPONSE/PREPAREDNESS

The use of the WallWalker™ would not be applicable to use in an emergency response situation.

Emergency response/preparedness must be part of every hazardous waste site safety and health plan. In addition to credible site emergencies, site personnel must plan for credible emergencies in connection with the WallWalker™.

All precautions used when responding to an emergency situation at the site will apply. Before entering an area where the scabber is being used, the equipment needs to be completely shut down (de-energized).

This technology does not appear to present any conditions that would lead to out of the ordinary emergencies other than crushing injuries due to the weight of the scabber and the assemblies.

SECTION 8 - REGULATORY/POLICY ISSUES

The site safety and health personnel where the WallWalker™ technology is being used need to be concerned with safety and health regulations applicable to the issues discussed above. Regulations that apply may be divided into four categories. Core requirements are those regulations that would apply to any hazardous waste work site, regardless of the type of job. Technology specific requirements are those regulations that apply due to the specific technology being used. Special requirements are standards and policies that are specific to the technology itself and are required by reference in a regulation. Best management practices are not required, but are recommended by organizations such as the American National Standards Institute (ANSI), NIOSH, Department of Energy (DOE), National Fire Protection Association (NFPA), etc. These regulations/standards may include but not be limited to the following:

Core requirements:

- ◆ OSHA 29 CFR 1926.25 Housekeeping
- ◆ OSHA 29 CFR 1910.141 Sanitation (1910.141(a)(3) covers housekeeping)
- ◆ OSHA 29 CFR 1926 Subpart Z Toxic and Hazardous Substances
- ◆ OSHA 29 CFR 1910 Subpart Z Toxic and Hazardous Substances
- ◆ OSHA 29 CFR 1926.59 Hazard Communication

- ◆ OSHA 29 CFR 1910.1200 Hazard Communication
- ◆ OSHA 29 CFR 1926.64 Process Safety Management of Highly Hazardous Chemicals
- ◆ OSHA 29 CFR 1910.119 Process Safety Management of Highly Hazardous Chemicals
- ◆ OSHA 29 CFR 1926.65 Hazardous Waste Operations and Emergency Response
- ◆ OSHA 29 CFR 1910.120 Hazardous Waste Operations and Emergency Response
- ◆ Occupational Safety and Health Act 1970(5)(a)(1) General Duty Clause

Technology Specific Requirements:

- ◆ OSHA 29 CFR 1926 Subpart K Electrical
- ◆ OSHA 29 CFR 1910 Subpart S Electrical
- ◆ OSHA 29 CFR 1910 Subpart O Machinery and Machine Guarding
- ◆ OSHA 29 CFR 1910.147 The Control of Hazardous Energy (Lockout/Tagout)
- ◆ OSHA 29 CFR 1926 Subpart L Scaffolding
- ◆ OSHA 29 CFR 1910.28 Safety Requirements for Scaffolding
- ◆ OSHA 29 CFR 1926 Subpart X Stairways and Ladders
- ◆ OSHA 29 CFR 1910 Subpart D Walking Working Surfaces
- ◆ OSHA 29 CFR 1926.52 Occupational Noise Exposure
- ◆ OSHA 29 CFR 1910.95 Occupational Noise Exposure
- ◆ OSHA 29 CFR 1926.103 Respiratory Protection
- ◆ OSHA 29 CFR 1910.134 Respiratory Protection
- ◆ OSHA 29 CFR 1926.102 Eye and Face Protection
- ◆ OSHA 29 CFR 1910.133 Eye and Face Protection

- ◆ OSHA 29 CFR 1926.28 Personal Protective Equipment
- ◆ OSHA 29 CFR 1910.132 General Requirements (Personal Protective Equipment)
- ◆ OSHA 29 CFR 1926.23 First Aid and Medical Attention
- ◆ OSHA 29 CFR 1910.151 Medical Services and First Aid

Best Management Practices:

- ◆ ACGIH Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices

In addition to the above regulations and policies, it is imperative that all workers have appropriate and adequate training for the task and associated safety and health conditions. Training that would be required may be divided into four categories. Core training is that which is required for anyone entering a hazardous waste site to perform work, regardless of the type of job. Technology specific training is that training that is specific to the technology and required by safety and health standards. Special training is that which is specific to the technology to assure the worker is adequately trained for the task, but is not necessarily required by safety and health standards. Best management practices are trainings that while not mandated by health and safety standards, provide information and knowledge to the worker that will allow the worker to perform his/her job safely. Training to be applied for the centrifugal shot blast technology may include but not be limited to:

Core Training Requirements:

- ◆ HAZWOPER
- ◆ HAZCOM

Technology Specific Training:

- ◆ Respiratory Protection
- ◆ Hearing Conservation
- ◆ Personal Protective Equipment
- ◆ Electrical Safety

- ◆ Lockout/Tagout
- ◆ Scaffolding Safety
- ◆ Ladder Safety

Special training:

- ◆ Job specific training for equipment operation

Best Management Practice training:

- ◆ Ergonomics (proper lifting, bending, stooping)
- ◆ Heat stress (learning to recognize signs and symptoms)
- ◆ CPR/First Aid/Emergency Response/Blood-borne Pathogens
- ◆ Hand Signal Communication
- ◆ Construction Safety (OSHA 500) and/or General Industry Safety (OSHA 501)

SECTION 9 - OPERATIONAL CONSIDERATIONS & RECOMMENDATIONS

Recommendations made in this section for improved worker safety and health take into consideration the operation of the WallWalker™ with the VAC-PAC®. Specific recommendations include:

- ◆ It needs to be assured that workers are aware of the tripping hazards associated with air lines, vacuum hoses, electrical lines, and computer lines that are necessary to operate the equipment. Keeping these as orderly as possible in compliance with good housekeeping regulations will help avoid injury due to tripping.
- ◆ If a fitting on an air line fails, the flying hose has the potential to cause severe injury. A safety line connected to the male and female parts of the fitting would keep the hose from becoming a flying object.
- ◆ There are electrical hazards associated with the WallWalker™, VAC-PAC®, and the computerized operator station. They need GFCI and appropriate grounding.
- ◆ There is concern for ergonomic stressors. During setup and tear down there is the potential for sprain/strain to the back, shoulders, arms, and legs from lifting,

bending, moving the cart with the scabbling head on it, and attaching the positioning system to the surface to be scabbled.

Attaching the positioning system to the vertical surface requires the worker to lift the reeving motor drive assembly above the head, hold it in place, and anchor it with bolts. The assembly weighs approximately 50 pounds. This places a great deal of stress on the back, shoulders, neck, and arms. A mechanical lift for hoisting and holding the assembly in place while it is attached or using a scissor lift and having two workers attach the assembly would help to alleviate many of these stressors.

Moving the cart with the scabbling head on it has the potential for sprain/strain to the back, shoulders, and arms from bending to push the cart. The scabbling head weighs approximately 450 pounds. Using a cart that is adjustable in height so the worker will not have to bend and having a handle on the cart to push or pull instead of pushing/pulling on the cart itself, will help to lessen the stress placed on the back. Using a mechanical means such as a fork lift or a powered cart would eliminate the need for the worker to push/pull the cart and therefore, eliminate the ergonomic stressors. Additionally, workers should have ergonomics training to include proper lifting techniques.

- ◆ Dust exposure was minimal at the operators station during the operation of the WallWalker™. The samples taken at the head of the scabbler were in excess of the OSHA PEL and the ACGIH TLV but the sampling filters contained grit and large pieces of concrete. It is recommended that the vacuum system be evaluated to determine if an increase in capture velocity would help with this problem.
- ◆ The only time any visible dust was seen was when the scabbling head lost its seal with the wall. This frequently happened when the seal hit a bump or uneven area on the wall. It is recommended that a different type of seal that will not be as susceptible to the uneven surface, such as a brush seal, be considered for on the face of the scabbler.
- ◆ There is potential for noise exposure in excess of the allowable limits during the operation of the WallWalker™. All noise monitoring, with the exception of one sampling period, showed values in excess of the OSHA PEL and ACGIH TLV for an 8-hour work shift. It is recommended that engineering controls be evaluated to control the noise levels the operator is exposed to during operation. In addition to feasible engineering controls, administrative controls, and adequate hearing protection must be incorporated during operation. One potential solution would be to locate the operator's control panel at a greater distance from the noise.

- ◆ The operator is not required to be at the work station at all times during the operation of the WallWalker™. Once the WallWalker™ is programmed and started, the operator can walk away at any time and the system will continue. This could allow the WallWalker™ to keep operating even if an emergency situation occurs. This could lead to injury to a worker in the area. Standard Operating Procedures (SOP's) need to be developed that require the operator to stay with the control panel at all times. Placing cameras in the area where the WallWalker™ is operating would keep the operator from leaving the control panel to enter the operations area to see what was happening.
- ◆ The computer screen for the control panel is a "touch" screen. There was no type of label to indicate this. Someone could touch the screen and change the WallWalker™ settings. This could lead to the WallWalker™ changing its path and striking someone or something in the area. It is recommended that the screen be labeled "Touch Screen", "Operation in Progress", "DO NOT TOUCH" or some other similar verbiage.
- ◆ During the testing demonstration, it was indicated by the technology developer that the computer wires running from the control station to the WallWalker™ were somewhat delicate and should not be trampled on. These wires are likely to be trampled on during the course of operation. If they are delicate and damage to them could easily result in loss of control of the scabbler, it is recommended that they not be laid on the ground or that they be run through some type of conduit to protect them.
- ◆ If the operator's station is used outdoors, the glare on the computer screen has the potential to make it very difficult if not impossible to see the screen. It is recommended that a shield be built to protect the computer screen from glare. This would also be useful indoors if the lighting causes glare on the screen.
- ◆ There are holes on the back portion of the scabbling head that are for access into the system for maintenance and/or repair. The holes are covered with red plastic caps but if the caps are removed during operation the scabbler continues to operate. The fingers/hand could be inserted and severe injury caused. An interlock needs to be in place where if the cap is removed during operation, the system shuts down. Additionally, these areas need to be labeled as a moving part. For example, "Do not remove cap or insert fingers/hand during operation".
- ◆ The WallWalker™, which weighs approximately 450 pounds, is suspended from the wall by the computer controlled positioning system. The system is suspended from two separate cables from the left and right side of the wall. The motor assemblies, weighing approximately 50 pounds each, are attached to the wall with bolts. If a wall was to collapse during or after the WallWalker™ was attached, there is the potential to cause severe injury or fatalities. It is recommended that the integrity of the wall to which the WallWalker™ is being

attached is checked prior to attachment to assure that it will hold the weight. Additionally, the vibration of the wall that the WallWalker™ may create needs to be taken into consideration.

It also needs to be assured that the bolts being used to attach the system to the wall and the cables holding the scabbling head are rated for the weight they are suspending. The breaking strength of the cable needs to be considered in relation to the stress that will be placed on it as the WallWalker™ moves along the horizontal and vertical axis of the wall. A program needs to be developed to assure that the cables are inspected on a regular basis.

- ◆ Attaching the system to the wall requires that the worker be able to reach the top portion of the wall. Reaching the top portion of the wall requires the use of scaffolding or lift such as a scissor lift. Proper precautions must be taken including compliance with the OSHA scaffold program. No one should be permitted to work in the area of the scaffolding without a hard hat.

Ladders are not an appropriate method for reaching the upper wall to attach the system. The worker cannot climb the ladder with the attachments nor anchor them to the wall and still maintain three points of contact.

- ◆ If the system loses power, the WallWalker™ will not stay suspended at its location at that time, but will travel to the bottom of the wall. This has the potential to cause injury by striking someone who would be in the area at the time. There needs to be a fail safe brake on the system to hold it if power is lost. Additionally, no one should be allowed to be near or under the suspended scabbling head. If something must be done to it, it should be lowered to a floor location, turned off, and proper lockout/tagout procedures used.
- ◆ When changing-out a full drum the operator must use the hand controls on the VAC-PAC®. They are difficult to reach (the operator is stooping and must reach above shoulder and head height) and they are used blindly since the operator cannot look at the gauges and the drum/drum seal at the same time. Moving the controls to a position where they are easily accessible and visible to the operator during drum change is recommended.
- ◆ A full drum may weigh 220 pounds or more. This presents great potential for back injury when two operators lift the drum for change-out. It is recommended that the system be evaluated for use with a mechanical lifting system.
- ◆ The roughing filters are changed directly into a plastic bag and disposed. If the plastic bag where to tear or rip there is the potential for the operator to come into contact with the contaminants. It is recommended that the operator wear gloves while changing the roughing filter. In addition, the bag was held in place by duct

tape. It is recommended that some type of hooks be used to hold the bag in place instead.

- ◆ When changing out a full drum, a cardboard disk is used as a barrier between the drum and the filter unit. This disk is held in place by the vacuum suction. If there was a loss in vacuum pressure during change out the disk will fall and there is an increase in the potential for exposure to the contaminant. It is recommended that a system such as hooks be designed to hold the disk in place in the event that vacuum pressure is lost.

APPENDIX A REFERENCES

**Occupational Safety and Health Standards for General Industry, 29 CFR Part 1910,
Occupational Safety and Health Administration United States Department of Labor**

**Occupational Safety and Health Standards for the Construction Industry, 29 CFR Part
1926, Occupational Safety and Health Administration United States Department of
Labor**

**Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents and
Biological Exposure Indices (BEIs), American Conference of Governmental Industrial
Hygienists, 1995-1996**

**The NIOSH compendium of hearing protection devices, U.S. Department of Health and
Human Services, Public Health Service, Center for Disease Control and Prevention,
October 1994**

APPENDIX B IH SAMPLING DATA

Pentek, Inc. WallWalker TM Total Dust Sampling			
6/26/97	062697-FIU-001	Total dust	64.9 mg/m ³
6/26/97	062697-FIU-002	Total dust	00.00 mg/m ³
6/26/97	062697-FIU-003	Blank	00.00 mg/m ³
6/27/97	062797-FIU-004	Total dust	00.00 mg/m ³
6/22/97	062297-FIU-005	Total dust	106.5 mg/m ³
6/27/97	062797-FIU-006	Blank	0.00 grams
6/27/97	062797-FIU-007	Total dust	46.7 mg/m ³

* The OSHA PEL for total dust is 15 mg/m³ and the ACGIH TLV is 10 mg/m³. Current sampling was conducted for total dust. The need to sample for respirable dust and silica has to be considered during concrete decontamination and decommissioning activities.

NOISE SAMPLING

The percentage of time spent at each decibel can be obtained from the graph. As shown, 8.359% of the time the noise exposure was less than 85dBA which means only 91.641% of the time was spent at sound levels above 85 dBA. OSHA requires that a hearing conservation program be initiated if the 8-hour TWA is 85 dBA.

NOISE SAMPLING

Amplitude Distribution Data

<85.0dB: 15.036% 85.0—>85.9dB: 14.581% Ln(70.383)=85.9dB

The percentage of time spent at each decibel can be obtained from the graph. As shown, 15.036% of the time the noise exposure was less than 85dBA which means only 84.964% of the time was spent at sound levels above 85 dBA. OSHA requires that a hearing conservation program be initiated if the 8-hour TWA is 85 dBA.

NOISE SAMPLING

Amplitude Distribution Data

The percentage of time spent at each decibel can be obtained from the graph. As shown, 6.009% of the time the noise exposure was less than 85dBA which means only 93.991% of the time was spent at sound levels above 85 dBA. OSHA requires that a hearing conservation program be initiated if the 8-hour TWA is 85 dBA.

NOISE SAMPLING

Amplitude Distribution Data

<85.0dB: 7.381% 85.0-->85.9dB: 0.041% Ln(92.578)=85.9dB

The percentage of time spent at each decibel can be obtained from the graph. As shown, 7.381% of the time the noise exposure was less than 85dBA which means only 92.619% of the time was spent at sound levels above 85 dBA. OSHA requires that a hearing conservation program be initiated if the 8-hour TWA is 85 dBA.

NOISE SAMPLING

Amplitude Distribution Data

The percentage of time spent at each decibel can be obtained from the graph. As shown, 9.955% of the time the noise exposure was less than 85dBA which means only 90.045% of the time was spent at sound levels above 85 dBA. OSHA requires that a hearing conservation program be initiated if the 8-hour TWA is 85 dBA.

NOISE SAMPLING

Amplitude Distribution Data

The percentage of time spent at each decibel can be obtained from the graph. As shown, 9.962% of the time the noise exposure was less than 85dBA which means only 90.038% of the time was spent at sound levels above 85 dBA. OSHA requires that a hearing conservation program be initiated if the 8-hour TWA is 85 dBA.

APPENDIX C ACRONYM SHEET

ANSI	-	American National Standards Institute
ACGIH	-	American Conference of Governmental Industrial Hygienists
CFR	-	Code of Federal Regulations
DC	-	direct current
DOE	-	Department of Energy
FIU	-	Florida International University
GFCI	-	ground fault circuit interrupter
HAZCOM	-	Hazard Communication
HAZWOPER	-	Hazardous Waste Operations and Emergency Response
HEPA	-	high efficiency particulate air (filter)
NFPA	-	National Fire Protection Association
NIOSH	-	National Institute of Occupational Safety and Health
OSHA	-	Occupational Safety and Health Administration
PEL	-	permissible exposure limit
PPE	-	personal protective equipment
SOP's	-	standard operating procedures
TLV	-	threshold limit value
TWA	-	time weighted average

PENTEK, INC.
WallWalker™
TABLE OF CONTENTS

ACKNOWLEDGEMENTS.....	ii
EXECUTIVE SUMMARY	iii
SECTION 1 – SUMMARY	1
Technology Description	1
Key Results	2
SECTION 2 - SYSTEM OPERATION.....	2
SECTION 3 - HEALTH AND SAFETY EVALUATION	3
General Health and Safety Concerns	3
Core Issues	4
Best Management Practices.....	5
Industrial Hygiene Monitoring	5
Human Factors Interface	8
Technology Applicability	8
SECTION 4 - EMERGENCY RESPONSE/PREPAREDNESS	8
SECTION 5 - REGULATORY POLICY ISSUES.....	9
Core Requirements	9
Technology Specific Requirements	10
Best Management Practices.....	10
Core Training Requirements.....	11
Technology Specific Training.....	11
Special Training	11
Best Management Practice Training.....	11
SECTION 6 - OPERATIONAL CONSIDERATIONS AND RECOMMENDATIONS	12
APPENDIX A - REFERENCES	16
APPENDIX B - INDUSTRIAL HYGIENE DATA.....	17
APPENDIX C - ACRONYMS	24

ACKNOWLEDGEMENTS

The human factors assessment of Pentek, Inc. WallWalker™ was conducted under support of the U.S. Department of Energy's Federal Energy Technology Center, under cooperative agreement DE-FC21-95MC32260 with the Operating Engineers National Hazmat Program. The Operating Engineers National Hazmat Program would like to thank the following people for their participation on the "research action team" and the professional expertise they provided for this assessment:

Barbara McCabe
Pat Bell
Lane Parker

Operating Engineers National Hazmat Program
Operating Engineers National Hazmat Program
Operating Engineers Local Union 470

EXECUTIVE SUMMARY

The Pentek, Inc. WallWalker™ consists of a remotely operated, computer controlled positioning system interfaced with a scabber for the removal of coatings and concrete from vertical surfaces. The integrated WallWalker™ remote positioning/decontamination system consists of a motion control system, scabber head interface, and a HEPA vacuum system.

The motion control system precisely controls the position, velocity, and acceleration of the scabber head over the entire vertical plane. This patented system works independently controlling the lengths of two separate cables that hang from the upper left and right sides of the wall. Both cables are joined together at a single point with a yoke and clevis which defines the attachment point of the end effector (scabber head).

The operator interface consists of a touch control screen for entering the physical/geometric setup parameters and motion profiles. The software (Parasol II) is flexible in accommodating variations in the initial conditions for each of the two reeving motor drive assemblies and their relationship to the wall.

The WallWalker™ scabber head utilizes a "low-friction" static seal by maintaining a vacuum flow for dust and contamination control, while maximizing the vacuum pressure between the scabber and the wall.

Vacuum flow is provided via a VAC-PAC® vacuum system which has two stage positive filtration sufficient to support safe and efficient vacuuming of materials. First stage roughing filter efficiency is 95% at 1 micron, with second stage high efficiency particulate air filter efficiency of 99.97% at 0.3 microns.

During the assessment sampling was conducted for dust and noise and general observational techniques were conducted for ergonomics. General observational techniques for ergonomics showed the potential for some ergonomic problems during surface coating removal using the WallWalker™. During setup and tear down there is the potential for sprain/strain to the back, shoulders, arms, and legs from lifting, bending, moving the cart with the scabbling head on it, and attaching the positioning system to the surface to be scabbled. Attaching and removing the reeving motor drive assembly presents particular concerns for ergonomic stressors in these areas.

Area dust sampling was conducted for total dust during operation of the WallWalker™. There were three operators and they changed out of the work area throughout the testing demonstration. Therefore, area sampling was conducted at the operator's work station to determine the potential exposures over a longer period of time. All dust sampling conducted in the area of the operator's station showed results below the OSHA PEL and the ACGIH TLV of 15 mg/m³ and 10 mg/m³ respectively for total dust. Sampling values shown

were 0.00 mg/m³ and 0.00 mg/m³. All dust sampling conducted at the scabbling head showed results in excess of the OSHA PEL and ACGIH TLV. Sampling values shown were 64.9 mg/m³, 46.7 mg/m³, and 106.5 mg/m³. All of the samples showing elevated levels also had visible grit and larger pieces of concrete on the sampling filters. This may in part explain these higher results.

Area noise measurements were taken at the operator's station and in the area of the ancillary equipment. Noise measurements at the operator's station showed noise doses of 20.51% which gives an 8-hour time weighted average (TWA) of 78.7 dBA, 100.62% (TWA – 90 dBA), 124.90% (TWA – 91.6 dBA), and 128.20% (TWA – 91.8 dBA). Noise measurements at the ancillary equipment showed noise doses of 61.7% (TWA – 87.5 dBA) and 118.88% (TWA – 91.2 dBA).

The OSHA allowable PEL for noise is a 100% dose or an 8-hour TWA of 90 dBA. The above noise doses and TWA's show noise to be a potential exposure hazard for the operator of the WallWalker™ and ancillary equipment. While the operator's distance from the WallWalker™ and the amount of time spent in the area where the scabbling is taking place can affect the operator's exposure level, the majority of the TWA's during the testing demonstration were at a level where the operator would be required to be included in a hearing conservation program. Feasible engineering controls, administrative controls, and personal protective equipment (hearing protection devices) need to be used as appropriate.

Recommendations for improved worker safety and health during use of the WallWalker™ include: 1. keeping all hoses and lines as orderly as possible in compliance with good housekeeping requirements; 2. ergonomic training to include techniques in lifting, bending, stooping, twisting, etc.; 3. a safety fitting on airlines; 4. GFCI and appropriate grounding on all electrical connections; 5. an evaluation of the capture velocity of the vacuum system; 6. an evaluation of engineering controls for noise exposure; 7. require the operator to always be in attendance at the control panel; 8. label the control screen at the control panel "touch screen"; 9. and design an interlock so the WallWalker™ will not continue to operate if the plastic caps on the access holes in the back of the scabbling head are removed.

PENTEK, INC.
WALLWALKER™
HUMAN FACTORS ASSESSMENT

SECTION 1 - SUMMARY

TECHNOLOGY DESCRIPTION

The Pentek, Inc. WallWalker™ technology was tested and is being evaluated at Florida International University (FIU) as a baseline technology. In conjunction with FIU's evaluation of efficiency and cost, this report covers the hazard analysis and safety evaluation.

The WallWalker™ consists of a remotely operated, computer controlled positioning system interfaced with a scabber for the removal of coatings and concrete from vertical surfaces. The integrated WallWalker™ remote positioning/decontamination system consists of a motion control system, scabber head interface, and a HEPA vacuum system.

The motion control system precisely controls the position, velocity, and acceleration of the scabber head over the entire vertical plane. This patented system works independently, controlling the lengths of two separate cables that hang from the upper left and right sides of the wall. Both cables are joined together at a single point with a yoke and clevis which defines the attachment point of the end effector (scabber head).

The operator interface consists of a touch control screen for entering the physical/geometric setup parameters and motion profiles. The software (Parasol II) is flexible in accommodating variations in the initial conditions for each of the two reeving motor drive assemblies and their relationship to the wall.

The WallWalker™ scabber head utilizes a "low-friction" static seal by maintaining a vacuum flow for dust and contamination control, while maximizing the vacuum pressure between the scabber and the wall.

Vacuum flow is provided via a VAC-PAC® vacuum system which has two stage positive filtration sufficient to support safe and efficient vacuuming of materials. First stage roughing filter efficiency is 95% at 1 micron, with second stage high efficiency particulate air (HEPA) filter efficiency of 99.97% at 0.3 microns.

KEY RESULTS

The safety and health evaluation during the testing demonstration focused on two main areas of exposure: dust and noise. Dust and noise exposure was potentially significant. Several of the air samples taken for total dust were in excess of the Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) of 15 mg/m³ and the American Conference of Industrial Hygienists (ACGIH) threshold limit value (TLV) of 10 mg/m³ but grit and/or larger pieces of concrete were visible on the air sampling filter for these samples. Noise monitoring showed levels in excess of the OSHA action level of 85 dBA but only a couple of sampling periods showed noise levels above the PEL of 90 dBA. This and the potential for dust exposure will be discussed in greater detail in the Industrial Hygiene section of this report. Other safety and health hazards found were ergonomics, heat stress, tripping hazards, electrical hazards, machine guarding, and lockout/tagout.

SECTION 2 - SYSTEM OPERATION

The Pentek WallWalker™ consists of a remotely operated, computer controlled positioning system interfaced with a scabblers for the removal of coatings and concrete from vertical surfaces. The integrated WallWalker™ remote positioning/decontamination system consists of a motion control system, scabblers head interface, and a HEPA vacuum system.

The motion control system precisely controls the position, velocity, and acceleration of the scabblers head over the entire vertical plane. This patented system works independently controlling the lengths of two separate cables that hang from the upper left and right sides of the wall. Both cables are joined together at a single point with a yoke and clevis which defines the attachment point of the end effector (scabblers head).

Figure 1. WallWalker™ suspended from "quasi-infinite" cable.

The length of each cable is controlled by a DC brushless servo motor that is attached to a cable reeving device. The once through device is unique in its ability to use "quasi-infinite" cable lengths so the system can be used on extremely large surface areas. The absolute accuracy of cable length adjustment is to within 0.01 inches. Constant velocity is user defined up to 60 feet per minute. The two reeving motor drive assemblies can be attached directly to the wall by mechanical methods such as bolting, clamping, vacuum suction or magnetics. They can also be attached to a

"false" compression beam and suspended above the wall.

The operator interface consists of a touch control screen for entering the physical/geometric setup parameters and motion profiles. The software (Parasol II) is flexible in accommodating variations in the initial conditions for each of the two reeving motor drive assemblies and their relationship to the wall. Several of the basic motion profiles include straight line, raster pattern, circle, and alpha-numeric characters.

The WallWalker™ scabblers head utilizes a "low-friction" static seal by maintaining a vacuum flow for dust and contamination control, while maximizing the vacuum pressure between the scabblers and the wall.

Inside the scabbling head is a triangular array of three pneumatically operated scabblers. Each scabblers is mounted on an independent suspension to allow for variations in surface height and to maintain optimum cutting force against the wall. The array of three scabblers is rotated about the assembly's central axis during scabbling to maintain a uniformly keyed, even surface profile as the assembly transverses across the wall at a constant velocity. The depth of concrete removal in a single pass can be regulated from 1/16 to 1/4-inch by controlling the velocity of the scabblers head over the surface. Greater depth of removal can be achieved with multiple passes.

Vacuum flow is provided via a VAC-PAC® vacuum system which has two stage positive filtration sufficient to support safe and efficient vacuuming of materials. First stage roughing filter efficiency is 95% at 1 micron, with second stage HEPA efficiency of 99.97% at 0.3 microns. The VAC-PAC® design is Pentek's exclusive controlled seal drum fill system, which allows the operator to fill, seal, remove, and replace the waste drum under controlled vacuum conditions. This assures positive control of waste and dust and minimizes the possibility of releasing airborne contamination during drum changing operations.

Figure 2. VAC-PAC® vacuum system.

SECTION 3 - HEALTH AND SAFETY EVALUATION

GENERAL SAFETY AND HEALTH CONCERNS

Personnel where the WallWalker™ scabbling technology is being used need to be concerned with safety and health issues. Issues that personnel need to be cognizant of may be divided into two categories. Core issues are those that are based on current safety and health regulatory requirements. Best management practices are related to issues that are not based on current safety and health regulations, but are key elements in preventing worker injury and illness on the job.

Safety and health issues of concern with the WallWalker™ scabbling technology included:

Core Issues:

- ◆ Housekeeping - The air lines, electrical lines, vacuum hoses, and computer lines are necessary for system operation but are tripping hazards. Stringent housekeeping must be addressed.
- ◆ Electrical hazards - The electric cords necessary to operate the equipment may present electrical hazards and the need for ground fault circuit interrupters (GFCI) and grounding must be evaluated.
- ◆ Lockout/Tagout - Before any maintenance or decontamination activities are conducted hazardous energy sources need to be eliminated. A lockout/tagout program will need to be developed.
- ◆ Pinch points - The potential exists for the operator to have his/her fingers/hands crushed during maintenance/repair if the scabblers were to be activated during this time. The back of the scabbling head has openings that can be accessed during operation. These areas need to be labeled as pinch points. The head needs to be evaluated for interlocks on the covers for these areas.
- ◆ Fall hazard - Installation of the WallWalker™ to the surface to be scabbled requires workers to work from a ladder, scaffolding, or elevated platform. This presents the potential for fall hazards. Fall protection may be required. If scaffolding is being used, compliance with the OSHA scaffold standard must be assured.
- ◆ Noise - Noise levels were found to be above the OSHA action limit with potential for exposure above the PEL. This will be discussed in greater detail in the Industrial Hygiene section of this report.
- ◆ Dust - Some visible dust was seen at the blast head when the seal with the wall was disrupted. Several of the air samples taken for total dust were in excess of the OSHA PEL of 15 mg/m³ and the ACGIH TLV of 10 mg/m³ but grit and/or larger pieces of concrete were visible on the air sampling filter for these samples. This will be discussed in greater detail in the Industrial Hygiene section of this report.

Best management practices:

- ◆ Diesel exhaust - Operation of the WallWalker™ requires an air compressor. If a diesel generated air compressor is used the potential exists for exposure to diesel exhaust. Diesel should not be exhausted indoors or where the exhaust can be pulled into an air intake.
- ◆ Heat stress - Workers are subjected to an increase in heat stress due to the need to utilize personal protective equipment (PPE). The user will need to develop a heat stress program for the environment in which the scabber is being used, taking into consideration any PPE that may need to be utilized, ambient temperatures, etc.
- ◆ Ergonomics - There are ergonomic stressors associated with the use of the WallWalker™, in particular during setup and tear down. There is potential for stress/strain to the back, shoulders, arms, and legs.
- ◆ Communication - Due to the noise generated by the technology during operation, communication may be difficult. Personnel working in the area need to be familiar with hand signals and use them as appropriate.
- ◆ Fall from above hazards - There is the potential for items to be dropped by personnel working at an elevation to attach the WallWalker™ to the surface to be scabbled. Anyone working on the ground in this area needs to be wearing a hard hat.

INDUSTRIAL HYGIENE MONITORING

During this testing demonstration with the WallWalker™, sampling was conducted for dust and noise. In addition, the wet-bulb globe temperature was monitored to evaluate heat stress and observational evaluation was conducted for ergonomics.

Through general observational techniques the potential for ergonomic stressors was evaluated during the testing demonstration. During setup and tear down there is the potential for sprain/strain to the back, shoulders, arms, and legs from lifting, bending, moving the cart with the scabbling head on it, and attaching the positioning system to the surface to be scabbled.

Attaching the positioning system to the vertical surface requires the worker to lift the reeving motor drive assembly above the head, hold it in place, and anchor it with bolts. The assembly weighs approximately 50 pounds. This places a great deal of stress on the back, shoulders, neck, and arms. A mechanical lift for hoisting and holding the assembly in place while it is attached or using a scissor lift and having two workers attach the assembly would help to alleviate many of these stressors. Additionally, using

a ladder while anchoring the assembly does not allow the worker to maintain three points of contact while on the ladder. Therefore, a ladder should not be used for this purpose.

Moving the cart with the scabbling head on it has the potential for sprain/strain (from bending to push the cart) to the back, shoulders, and arms. The scabbling head weighs approximately 450 pounds. Using a cart that is adjustable in height so the worker will not have to bend and having a handle on the cart to push or pull instead of pushing/pulling on the cart itself, will help to lessen the stress placed on the back. Using a mechanical means, such as a fork lift or a powered cart, would eliminate the need for the worker to push/pull the cart and therefore, eliminate the ergonomic stressors.

Heat stress parameters were monitored using a Quest QuestTemp[®]15 Heat Stress Monitor. The wet-bulb globe temperature was used to determine the work/rest regimen in accordance with ACGIH recommendations. The wet-bulb globe temperature was adjusted for the type of clothing, including PPE, in accordance with ACGIH recommendations. While heat stress will be increased when wearing PPE, the overall heat stress response will vary from worker to worker. Each situation in which the current technology is used will need to be evaluated for the heat stress potential, taking into consideration the wet-bulb globe temperature, PPE in use, physical condition of the worker, and amount of worker acclimatization.

Dust monitoring was conducted with a sampling train consisting of an SKC IOM Inhalable dust sampler coupled with an MSA Escort Elf air sampling pump. Pre- and post-sampling calibration was accomplished using a BIOS International DryCal DC1 primary calibration system. Sampling filters were desiccated pre- and post-sampling and weighed on an OHAUS Scout Electronic Balance. Sampling was conducted in accordance with National Institute of Occupational Safety and Health (NIOSH) method 0500.

Area dust sampling was conducted for total dust during operation of the WallWalker[™]. There were three operators and they changed out of the work area throughout the testing demonstration. Therefore, area sampling was conducted at the operator's work station to determine the potential exposures over a longer period of time. All dust sampling conducted in the area of the operators station showed results below OSHA PEL and ACGIH TLV of 15 mg/m³ and 10 mg/m³ respectively. Sampling values shown were 0.0 mg/m³ and 0.0 mg/m³. All dust sampling conducted at the scabbling head showed results in excess of the OSHA PEL and ACGIH TLV. Sampling values shown were 64.9 mg/m³, 46.7 mg/m³, and 106.5 mg/m³. All of the samples showing these elevated levels also had visible grit and larger pieces of concrete on the sampling filters. This may in part explain these higher results.

Area noise monitoring was conducted during the operation of the blaster. As with dust sampling, since the operators were changing every 20-30 minutes, area monitoring was

conducted to determine the potential for exposure to noise over a longer period of time. Noise monitoring was conducted using Metrosonic db-3100 data logging noise dosimeters. Calibration was conducted pre- and post-monitoring using a Metrosonics CL304 acoustical calibrator.

Area noise measurements were taken at the operators station and in the area of ancillary equipment such as the VAC-PAC®. Area noise measurements at the operators station were taken for 2.55 hours (153 minutes), 8.21 hours (493 minutes), 7.18 hours (431 minutes), and 7.2 hours (434 minutes). This gives an 8-hour noise dose of 20.51% which gives an 8-hour time-weighted average (TWA) of 78.7 dBA, 100.62% (TWA-90.0 dBA), 124.90% (TWA-91.6 dBA), and 128.20% (TWA-91.8 dBA). If these noise levels were the same over an 8-hour period, projected noise doses would be 64.12% (TWA-86.9 dBA), greater than 100% (TWA-greater than 90.0 dBA), 138.91% (TWA-92.4 dBA), and 141.77% (TWA-92.5 dBA). During these time periods the noise levels were averaged for each one-minute period of time. An overall average was calculated yielding an average exposure level of 86.9 dB, 89.9 dB, 92.4 dB, and 92.5 dB. The maximum sound levels during the sampling periods were 116.0 dB, 96.6 dB, 100.8 dB, and 99.6 dB. The highest instantaneous sound pressure levels were greater than 140.0 dB, 123.6 dB, 121.9 dB, and 133.7 dB. The amount of time spent at each loudness level that comprises the exposures can be seen in Appendix B.

Area noise measurements at the ancillary equipment were taken for 6.95 hours (417 minutes) and 8.45 hours (507 minutes). This gives an 8-hour noise dose of 61.7% (TWA of 87.5 dBA) and 118.88% (TWA-91.2 dBA). If these noise levels were the same over an 8-hour period, projected noise doses would be 70.24% (TWA-87.5 dBA), greater than 100% (TWA-greater than 90.0 dBA). During these time periods the noise levels were averaged for each one-minute period of time. An overall average was calculated yielding an average exposure level of 87.5 dB and 90.7 dB. The maximum sound levels during the sampling periods were 96.3 dB and 112.0 dB. The highest instantaneous sound pressure levels were 126.2 dB and greater than 140.0 dB. The amount of time spent at each loudness level that comprises the exposures can be seen in Appendix B.

The OSHA allowable PEL for noise is a 100% dose or an 8-hour TWA of 90 dBA. The above noise doses and TWA's show noise to be a potential exposure hazard for the operator of the WallWalker™ and ancillary equipment. While the operator's noise dose is dependent on his/her distance from the WallWalker™ and amount of time spent in the area where the scabbling is taking place, the majority of the TWA's are at a level where the operator would be required to be included in a hearing conservation program. Feasible engineering controls, administrative controls, and personal protective equipment (PPE-hearing protection devices) need to be used as appropriate.

HUMAN FACTORS INTERFACE

The need to utilize different levels of PPE, such as Level A, B, C, or D will depend on the contaminants associated with the surface being decontaminated and the amount of dust being generated. Contaminants should be identified by the site characterization prior to the start of the decontamination job. The amount of dust being generated will be identified by air sampling conducted during operation of the WallWalker™.

The level of protection being utilized has the potential to cause several human factors interface problems. These may include but not be limited to a decrease in visibility, manual dexterity, and tactile sensation; an increase in heat stress; and an overall increase in physical stress.

TECHNOLOGY APPLICABILITY

The technology produced some visible dust when the seal with the wall was disrupted during operation. Dust samples taken at the operator's station were below the OSHA PEL and the ACGIH TLV. Dust samples taken at the scabbling head were above the OSHA PEL and ACGIH TLV but contained grit and larger pieces of concrete. Noise monitoring indicated that workers are likely be overexposed in accordance with the OSHA PEL and the ACGIH TLV after an 8-hour work shift.

The WallWalker™ will need to be disassembled to be decontaminated. This will not necessarily guarantee that the equipment will be "clean". Parts of the system may need to be considered consumables.

SECTION 4 - EMERGENCY RESPONSE/PREPAREDNESS

The use of the WallWalker™ would not be applicable to use in an emergency response situation.

Emergency response/preparedness must be part of every hazardous waste site safety and health plan. In addition to credible site emergencies, site personnel must plan for credible emergencies in connection with the WallWalker™.

All precautions used when responding to an emergency situation at the site will apply. Before entering an area where the scabber is being used, the equipment needs to be completely shut down (de-energized).

This technology does not appear to present any conditions that would lead to out of the ordinary emergencies other than crushing injuries due to the weight of the scabber and the assemblies.

SECTION 5 - REGULATORY/POLICY ISSUES

The site safety and health personnel where the WallWalker™ technology is being used need to be concerned with safety and health regulations applicable to the issues discussed above. Regulations that apply may be divided into four categories. Core requirements are those regulations that would apply to any hazardous waste work site, regardless of the type of job. Technology specific requirements are those regulations that apply due to the specific technology being used. Special requirements are standards and policies that are specific to the technology itself and are required by reference in a regulation. Best management practices are not required, but are recommended by organizations such as the American National Standards Institute (ANSI), NIOSH, Department of Energy (DOE), National Fire Protection Association (NFPA), etc. These regulations/standards may include but not be limited to the following:

Core requirements:

- ◆ OSHA 29 CFR 1926.25 Housekeeping
- ◆ OSHA 29 CFR 1910.141 Sanitation (1910.141(a)(3) covers housekeeping)
- ◆ OSHA 29 CFR 1926 Subpart Z Toxic and Hazardous Substances
- ◆ OSHA 29 CFR 1910 Subpart Z Toxic and Hazardous Substances
- ◆ OSHA 29 CFR 1926.59 Hazard Communication
- ◆ OSHA 29 CFR 1910.1200 Hazard Communication
- ◆ OSHA 29 CFR 1926.64 Process Safety Management of Highly Hazardous Chemicals
- ◆ OSHA 29 CFR 1910.119 Process Safety Management of Highly Hazardous Chemicals
- ◆ OSHA 29 CFR 1926.65 Hazardous Waste Operations and Emergency Response
- ◆ OSHA 29 CFR 1910.120 Hazardous Waste Operations and Emergency Response
- ◆ Occupational Safety and Health Act 1970(5)(a)(1) General Duty Clause

Technology Specific Requirements:

- ◆ OSHA 29 CFR 1926 Subpart K Electrical
- ◆ OSHA 29 CFR 1910 Subpart S Electrical
- ◆ OSHA 29 CFR 1910 Subpart O Machinery and Machine Guarding
- ◆ OSHA 29 CFR 1910.147 The Control of Hazardous Energy (Lockout/Tagout)
- ◆ OSHA 29 CFR 1926 Subpart L Scaffolding
- ◆ OSHA 29 CFR 1910.28 Safety Requirements for Scaffolding
- ◆ OSHA 29 CFR 1926 Subpart X Stairways and Ladders
- ◆ OSHA 29 CFR 1910 Subpart D Walking Working Surfaces
- ◆ OSHA 29 CFR 1926.52 Occupational Noise Exposure
- OSHA 29 CFR 1910.95 Occupational Noise Exposure
- ◆ OSHA 29 CFR 1926.103 Respiratory Protection
- ◆ OSHA 29 CFR 1910.134 Respiratory Protection
- ◆ OSHA 29 CFR 1926.102 Eye and Face Protection
- ◆ OSHA 29 CFR 1910.133 Eye and Face Protection
- ◆ OSHA 29 CFR 1926.28 Personal Protective Equipment
- ◆ OSHA 29 CFR 1910.132 General Requirements (Personal Protective Equipment)
- ◆ OSHA 29 CFR 1926.23 First Aid and Medical Attention
- ◆ OSHA 29 CFR 1910.151 Medical Services and First Aid

Best Management Practices:

- ◆ ACGIH Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices

In addition to the above regulations and policies, it is imperative that all workers have appropriate and adequate training for the task and associated safety and health conditions. Training that would be required may be divided into four categories. Core training is that which is required for anyone entering a hazardous waste site to perform work, regardless of the type of job. Technology specific training is that training that is specific to the technology and required by safety and health standards. Special training is that which is specific to the technology to assure the worker is adequately trained for the task, but is not necessarily required by safety and health standards. Best management practices are trainings that while not mandated by health and safety standards, provide information and knowledge to the worker that will allow the worker to perform his/her job safely. Training to be applied for the centrifugal shot blast technology may include but not be limited to:

Core Training Requirements:

- ◆ HAZWOPER
- ◆ HAZCOM

Technology Specific Training:

- ◆ Respiratory Protection
- ◆ Hearing Conservation
- ◆ Personal Protective Equipment
- ◆ Electrical Safety
- ◆ Lockout/Tagout
- ◆ Scaffolding Safety
- ◆ Ladder Safety

Special training:

- ◆ Job specific training for equipment operation

Best Management Practice training:

- ◆ Ergonomics (proper lifting, bending, stooping)
- ◆ Heat stress (learning to recognize signs and symptoms)

- ◆ CPR/First Aid/Emergency Response/Blood-borne Pathogens
- ◆ Hand Signal Communication
- ◆ Construction Safety (OSHA 500) and/or General Industry Safety (OSHA 501)

SECTION 6 - OPERATIONAL CONSIDERATIONS & RECOMMENDATIONS

Recommendations made in this section for improved worker safety and health take into consideration the operation of the WallWalker™ with the VAC-PAC®. Specific recommendations include:

- ◆ It needs to be assured that workers are aware of the tripping hazards associated with air lines, vacuum hoses, electrical lines, and computer lines that are necessary to operate the equipment. Keeping these as orderly as possible in compliance with good housekeeping regulations will help avoid injury due to tripping.
- ◆ If a fitting on an air line fails, the flying hose has the potential to cause severe injury. A safety line connected to the male and female parts of the fitting would keep the hose from becoming a flying object.
- ◆ There are electrical hazards associated with the WallWalker™, VAC-PAC®, and the computerized operator station. They need GFCI and appropriate grounding.
- ◆ There is concern for ergonomic stressors. During setup and tear down there is the potential for sprain/strain to the back, shoulders, arms, and legs from lifting, bending, moving the cart with the scabbling head on it, and attaching the positioning system to the surface to be scabbled.

Attaching the positioning system to the vertical surface requires the worker to lift the reeving motor drive assembly above the head, hold it in place, and anchor it with bolts. The assembly weighs approximately 50 pounds. This places a great deal of stress on the back, shoulders, neck, and arms. A mechanical lift for hoisting and holding the assembly in place while it is attached or using a scissor lift and having two workers attach the assembly would help to alleviate many of these stressors.

Moving the cart with the scabbling head on it has the potential for sprain/strain to the back, shoulders, and arms from bending to push the cart. The scabbling head weighs approximately 450 pounds. Using a cart that is adjustable in height so the worker will not have to bend and having a handle on the cart to push or pull instead of pushing/pulling on the cart itself, will help to lessen the stress

placed on the back. Using a mechanical means such as a fork lift or a powered cart would eliminate the need for the worker to push/pull the cart and therefore, eliminate the ergonomic stressors. Additionally, workers should have ergonomics training to include proper lifting techniques.

- ◆ Dust exposure was minimal at the operators station during the operation of the WallWalker™. The samples taken at the head of the scabblers were in excess of the OSHA PEL and the ACGIH TLV but the sampling filters contained grit and large pieces of concrete. It is recommended that the vacuum system be evaluated to determine if an increase in capture velocity would help with this problem.
- ◆ The only time any visible dust was seen was when the scabbling head lost its seal with the wall. This frequently happened when the seal hit a bump or uneven area on the wall. It is recommended that a different type of seal that will not be as susceptible to the uneven surface, such as a brush seal, be considered for on the face of the scabblers.
- ◆ There is potential for noise exposure in excess of the allowable limits during the operation of the WallWalker™. All noise monitoring, with the exception of one sampling period, showed values in excess of the OSHA PEL and ACGIH TLV for an 8-hour work shift. It is recommended that engineering controls be evaluated to control the noise levels the operator is exposed to during operation. In addition to feasible engineering controls, administrative controls, and adequate hearing protection must be incorporated during operation. One potential solution would be to locate the operator's control panel at a greater distance from the noise.
- ◆ The operator is not required to be at the work station at all times during the operation of the WallWalker™. Once the WallWalker™ is programmed and started, the operator can walk away at any time and the system will continue. This could allow the WallWalker™ to keep operating even if an emergency situation occurs. This could lead to injury to a worker in the area. Standard Operating Procedures (SOP's) need to be developed that require the operator to stay with the control panel at all times. Placing cameras in the area where the WallWalker™ is operating would keep the operator from leaving the control panel to enter the operations area to see what was happening.
- ◆ The computer screen for the control panel is a "touch" screen. There was no type of label to indicate this. Someone could touch the screen and change the WallWalker™ settings. This could lead to the WallWalker™ changing its path and striking someone or something in the area. It is recommended that the screen be labeled "Touch Screen", "Operation in Progress", "DO NOT TOUCH" or some other similar verbiage.

- ◆ During the testing demonstration, it was indicated by the technology developer that the computer wires running from the control station to the WallWalker™ were somewhat delicate and should not be trampled on. These wires are likely to be trampled on during the course of operation. If they are delicate and damage to them could easily result in loss of control of the scabblers, it is recommended that they not be laid on the ground or that they be run through some type of conduit to protect them.
- ◆ If the operator's station is used outdoors, the glare on the computer screen has the potential to make it very difficult if not impossible to see the screen. It is recommended that a shield be built to protect the computer screen from glare. This would also be useful indoors if the lighting causes glare on the screen.
- ◆ There are holes on the back portion of the scabbling head that are for access into the system for maintenance and/or repair. The holes are covered with red plastic caps but if the caps are removed during operation the scabblers continue to operate. The fingers/hand could be inserted and severe injury caused. An interlock needs to be in place where if the cap is removed during operation, the system shuts down. Additionally, these areas need to be labeled as a moving part. For example, "Do not remove cap or insert fingers/hand during operation".
- ◆ The WallWalker™, which weighs approximately 450 pounds, is suspended from the wall by the computer controlled positioning system. The system is suspended from two separate cables from the left and right side of the wall. The motor assemblies, weighing approximately 50 pounds each, are attached to the wall with bolts. If a wall was to collapse during or after the WallWalker™ was attached, there is the potential to cause severe injury or fatalities. It is recommended that the integrity of the wall to which the WallWalker™ is being attached is checked prior to attachment to assure that it will hold the weight. Additionally, the vibration of the wall that the WallWalker™ may create needs to be taken into consideration.

It also needs to be assured that the bolts being used to attach the system to the wall and the cables holding the scabbling head are rated for the weight they are suspending. The breaking strength of the cable needs to be considered in relation to the stress that will be placed on it as the WallWalker™ moves along the horizontal and vertical axis of the wall. A program needs to be developed to assure that the cables are inspected on a regular basis.

- ◆ Attaching the system to the wall requires that the worker be able to reach the top portion of the wall. Reaching the top portion of the wall requires the use of scaffolding or lift such as a scissor lift. Proper precautions must be taken including compliance with the OSHA scaffold program. No one should be permitted to work in the area of the scaffolding without a hard hat.

Ladders are not an appropriate method for reaching the upper wall to attach the system. The worker cannot climb the ladder with the attachments nor anchor them to the wall and still maintain three points of contact.

- ◆ If the system loses power, the WallWalker™ will not stay suspended at its location at that time, but will travel to the bottom of the wall. This has the potential to cause injury by striking someone who would be in the area at the time. There needs to be a fail safe brake on the system to hold it if power is lost. Additionally, no one should be allowed to be near or under the suspended scabbling head. If something must be done to it, it should be lowered to a floor location, turned off, and proper lockout/tagout procedures used.
- ◆ When changing-out a full drum the operator must use the hand controls on the VAC-PAC®. They are difficult to reach (the operator is stooping and must reach above shoulder and head height) and they are used blindly since the operator cannot look at the gauges and the drum/drum seal at the same time. Moving the controls to a position where they are easily accessible and visible to the operator during drum change is recommended.
- ◆ A full drum may weigh 220 pounds or more. This presents great potential for back injury when two operators lift the drum for change-out. It is recommended that the system be evaluated for use with a mechanical lifting system.
- ◆ The roughing filters are changed directly into a plastic bag and disposed. If the plastic bag where to tear or rip there is the potential for the operator to come into contact with the contaminants. It is recommended that the operator wear gloves while changing the roughing filter. In addition, the bag was held in place by duct tape. It is recommended that some type of hooks be used to hold the bag in place instead.
- ◆ When changing out a full drum, a cardboard disk is used as a barrier between the drum and the filter unit. This disk is held in place by the vacuum suction. If there was a loss in vacuum pressure during change out the disk will fall and there is an increase in the potential for exposure to the contaminant. It is recommended that a system such as hooks be designed to hold the disk in place in the event that vacuum pressure is lost.

APPENDIX A REFERENCES

**Occupational Safety and Health Standards for General Industry, 29 CFR Part 1910,
Occupational Safety and Health Administration United States Department of Labor**

**Occupational Safety and Health Standards for the Construction Industry, 29 CFR Part
1926, Occupational Safety and Health Administration United States Department of
Labor**

**Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents and
Biological Exposure Indices (BEIs), American Conference of Governmental Industrial
Hygienists, 1995-1996**

**The NIOSH compendium of hearing protection devices, U.S. Department of Health and
Human Services, Public Health Service, Center for Disease Control and Prevention,
October 1994**

APPENDIX B IH SAMPLING DATA

Pentek, Inc. WallWalker™ Total Dust Sampling			
6/26/97	062697-FIU-001	Total dust	64.9 mg/m ³
6/26/97	062697-FIU-002	Total dust	00.00 mg/m ³
6/26/97	062697-FIU-003	Blank	00.00 mg/m ³
6/27/97	062797-FIU-004	Total dust	00.00 mg/m ³
6/22/97	062297-FIU-005	Total dust	106.5 mg/m ³
6/27/97	062797-FIU-006	Blank	0.00 grams
6/27/97	062797-FIU-007	Total dust	46.7 mg/m ³

* The OSHA PEL for total dust is 15 mg/m³ and the ACGIH TLV is 10 mg/m³. Current sampling was conducted for total dust. The need to sample for respirable dust and silica has to be considered during concrete decontamination and decommissioning activities.

NOISE SAMPLING

Amplitude Distribution Data

The percentage of time spent at each decibel can be obtained from the graph. As shown, 8.359% of the time the noise exposure was less than 85dBA which means only 91.641% of the time was spent at sound levels above 85 dBA. OSHA requires that a hearing conservation program be initiated if the 8-hour TWA is 85 dBA.

NOISE SAMPLING

Amplitude Distribution Data

<85.0dB: 15.036% 85.0-->85.9dB: 14.581% $\text{Ln}(70.383)=85.9\text{dB}$

The percentage of time spent at each decibel can be obtained from the graph. As shown, 15.036% of the time the noise exposure was less than 85dBA which means only 84.964% of the time was spent at sound levels above 85 dBA. OSHA requires that a hearing conservation program be initiated if the 8-hour TWA is 85 dBA.

NOISE SAMPLING

Amplitude Distribution Data

The percentage of time spent at each decibel can be obtained from the graph. As shown, 6.009% of the time the noise exposure was less than 85dBA which means only 93.991% of the time was spent at sound levels above 85 dBA. OSHA requires that a hearing conservation program be initiated if the 8-hour TWA is 85 dBA.

NOISE SAMPLING

Amplitude Distribution Data

<85.0dB: 7.381% 85.0->85.9dB: 0.041% Ln(92.578)=85.9dB

The percentage of time spent at each decibel can be obtained from the graph. As shown, 7.381% of the time the noise exposure was less than 85dBA which means only 92.619% of the time was spent at sound levels above 85 dBA. OSHA requires that a hearing conservation program be initiated if the 8-hour TWA is 85 dBA.

NOISE SAMPLING

Amplitude Distribution Data

The percentage of time spent at each decibel can be obtained from the graph. As shown, 9.955% of the time the noise exposure was less than 85dBA which means only 90.045% of the time was spent at sound levels above 85 dBA. OSHA requires that a hearing conservation program be initiated if the 8-hour TWA is 85 dBA.

NOISE SAMPLING

Amplitude Distribution Data

<85.0dB: 9.962%

85.0-->85.9dB: 0.205%

$L_n(89.833)=85.9\text{dB}$

The percentage of time spent at each decibel can be obtained from the graph. As shown, 9.962% of the time the noise exposure was less than 85dBA which means only 90.038% of the time was spent at sound levels above 85 dBA. OSHA requires that a hearing conservation program be initiated if the 8-hour TWA is 85 dBA.

APPENDIX C ACRONYM SHEET

ANSI	-	American National Standards Institute
ACGIH	-	American Conference of Governmental Industrial Hygienists
CFR	-	Code of Federal Regulations
DC	-	direct current
DOE	-	Department of Energy
FIU	-	Florida International University
GFCI	-	ground fault circuit interrupter
HAZCOM	-	Hazard Communication
HAZWOPER	-	Hazardous Waste Operations and Emergency Response
HEPA	-	high efficiency particulate air (filter)
NFPA	-	National Fire Protection Association
NIOSH	-	National Institute of Occupational Safety and Health
OSHA	-	Occupational Safety and Health Administration
PEL	-	permissible exposure limit
PPE	-	personal protective equipment
SOP's	-	standard operating procedures
TLV	-	threshold limit value
TWA	-	time weighted average .

WHEELABRATOR BLASTRAC®

MAR 25 P 2: 32

TABLE OF CONTENTS

USDOE-FETC

ACKNOWLEDGEMENTS.....	iii
EXECUTIVE SUMMARY.....	iv
SECTION 1 – SUMMARY	1
Technology Description	1
Key Results	1
SECTION 2 - SYSTEM OPERATION.....	2
SECTION 3 - HEALTH AND SAFETY EVALUATION	3
General Health and Safety Concerns.....	3
Core Issues	3
Best Management Practices.....	4
Industrial Hygiene Monitoring	5
Human Factors Interface	7
Technology Applicability	7
SECTION 4 - JOB SAFETY ANALYSIS (JSA)	9
SECTION 5 - FAILURE MODES AND EFFECTS ANALYSIS (FMEA).....	13
SECTION 6 - TECHNOLOGY SAFETY DATA SHEET (TSDS)	14
SECTION 7 - EMERGENCY RESPONSE/PREPAREDNESS	23
SECTION 8 - REGULATORY POLICY ISSUES	23
Core Requirements	23
Technology Specific Requirements	24
Best Management Practices.....	25
Core Training Requirements	25
Technology Specific Training	26
Special Training.....	26
Best Management Practice Training	26
SECTION 9 - OPERATIONAL CONSIDERATIONS AND RECOMMENDATIONS	26

TABLE OF CONTENTS
(Continued)

APPENDIX A - REFERENCES	30
APPENDIX B - INDUSTRIAL HYGIENE DATA.....	31
APPENDIX C - ACRONYMS	32

ACKNOWLEDGEMENTS

The human factors assessment of Wheelabrator was conducted under support of the U.S. Department of Energy's Federal Energy Technology Center, under cooperative agreement DE-FC21-95MC32260 with the Operating Engineers National Hazmat Program. The Operating Engineers National Hazmat Program would like to thank the following people for their participation on the "research action team" and the professional expertise they provided for this assessment:

Barbara McCabe
David Mullins

Operating Engineers National Hazmat Program
Operating Engineers Local Union 132

EXECUTIVE SUMMARY

The Wheelabrator Blastrac® Model 1-15D coupled with Model 654-DC dust collection system was used during the testing demonstration. The Blastrac® is a surface preparation downblast machine for closed-cycle abrasive cleaning of horizontal surfaces. Surface and contaminant removal is accomplished by the impact of metallic abrasive thrown by controlled centrifugal force from a power driven bladed wheel. The thrown abrasive impacts the surface and rebounds upwardly into a rebound chamber, which then directs the abrasive into an airwash dust extractor. The dust extractor removes dust, scale, and other contaminants from the abrasive. The shot is then delivered by gravity to the storage hopper for reuse by the blast wheel. The Blastrac® is self-propelled by a variable speed electric drive system. The rate of speed the Blastrac® is traveling determines the depth of surface material removed.

During the assessment sampling was conducted for dust, and noise and general observational techniques were conducted for ergonomics. General observational techniques for ergonomics showed the potential for some ergonomic problems during surface coating removal using the Wheelabrator Blastrac®. There is potential for muscle/back stress and/or injuries due to bending, twisting, and lifting associated with setup, operation, maintenance, and decontamination. Of particular concern is the potential for back injury due to the need to manually remove and empty the disposal bin on the dust collector.

Personal air sampling was conducted on the equipment operator during blasting operations. A personal dust sampling value of 0.00 mg/m³ was obtained for the operator. This value does not exceed the Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) and the American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV) of 15 mg/m³ and 10 mg/m³ respectively for total dust. There was, however, a notable amount of shot left on the blasted surface. This could potentially become an airborne inhalation hazard, especially after the shot is pulverized and becomes a secondary source of dust. Due to this and the dust sampling being conducted in an outdoor environment with windy conditions, it is recommended that sampling be conducted while the shot blasting operation is being conducted in a closed environment. A complete air sampling plan for a site would need to be developed to include not only dust but other contaminants specific to the concrete decontamination project.

Personal noise monitoring on the operator showed noise levels ranging from 23.78% which would give an 8-hour time weighted average (TWA) of 79.6 dBA to 29.73% (TWA – 81.2 dBA).

The OSHA allowable PEL for noise is a 100% dose or an 8-hour TWA of 90 dBA. While the operator was not overexposed during the sampling periods but the

8-hour projected exposure levels would be above the OSHA "action level" and of 85 dBA and would require the operator to be included in a hearing conservation program.

Recommendations for improved worker safety and health during use of the Wheelabrator Blastrac® include: 1. keeping all hoses and lines as orderly as possible in compliance with good housekeeping requirements; 2. ergonomic training to include techniques in lifting, bending, stooping, twisting, etc.; 3. an automated dust collection system or a bagging system to contain the dust; 4. evaluation of the capture velocity on the vacuum system to determine if the an increase in capture velocity would keep less shot off of the surface being blasted; 5. use of HEPA filters in the dust collection system; 6. an adjustable control panel; 7. brakes on the wheels of the vacuum system; and 8. the use of faceshields in addition to safety glasses with sideshields or goggles.

WHEELABRATOR Blastrac® Shot Blast Cleaning System Human Factors Evaluation

SECTION 1 - SUMMARY

TECHNOLOGY DESCRIPTION

The Blastrac® shot blast technology was tested and is being evaluated at Florida International University (FIU) as a baseline technology. In conjunction with FIU's evaluation of efficiency and cost, this report covers the hazard analysis and safety evaluation. The Blastrac® is a commercially available technology and has been used for various projects at locations throughout the country.

The Wheelabrator Blastrac® Model 1-15D coupled with Model 654-DC dust collection system was used during the testing demonstration. The Blastrac® is a surface preparation downblast machine for closed-cycle abrasive cleaning of horizontal surfaces. Surface and contaminant removal are accomplished by the impact of metallic abrasive thrown by controlled centrifugal force from a power driven bladed wheel. The thrown abrasive impacts the surface and rebounds upwardly into a rebound chamber, which then directs the abrasive into an airwash dust extractor. The dust extractor removes dust, scale, and other contaminants from the abrasive. The shot is then delivered by gravity to the storage hopper for reuse by the blast wheel. The Blastrac® is self-propelled by a variable speed electric drive system. The rate of speed the Blastrac® is traveling determines the depth of surface material removed.

KEY RESULTS

The safety and health evaluation during the testing demonstration focused on two main areas of exposure: dust and noise. Dust exposure was minimal but noise exposure was significant. Further testing for each of these exposures is recommended because of the outdoor environment where the testing demonstration took place may cause the results to be inapplicable to enclosed operating environments, where it is feasible that the dust and noise levels will be higher. Other safety and health issues found were ergonomics, heat stress, tripping hazards, electrical hazards, and lockout/tagout.

SECTION 2 - SYSTEM OPERATION

The Wheelabrator Blastrac® Model 1-15D coupled with Model 654-DC dust collection system was used during the testing demonstration. The Blastrac® is a surface preparation downblast machine for closed-cycle abrasive cleaning of horizontal surfaces. Surface and contaminant removal are accomplished by the impact of metallic abrasive thrown by controlled centrifugal force from a power driven bladed wheel. The thrown abrasive impacts the surface and rebounds upwardly into a rebound chamber, which then directs the abrasive into an airwash dust extractor. The dust extractor removes dust, scale, and other contaminants from the abrasive. The shot is then delivered by gravity to the storage hopper for reuse by the blast wheel. The Blastrac® is self-propelled by a variable speed electric drive system. The rate of speed the Blastrac® is traveling determines the depth of surface material removed.

The Wheelabrator unit consists of a power driven four bladed wheel that throws abrasive by centrifugal force toward the surface to be blasted. The unit is enclosed in a guard housing of abrasive-resistant material and lined where necessary with replaceable wear plates. The wheel is driven by a 3600 RPM electrical motor. An impeller feeds the abrasive (shot) in controlled amounts onto the blades of the rotating wheel. The abrasive fed into the center of the rotating impeller is given its initial circular motion to direct it through the control cage opening and onto the wheel blades. The control cage directs the abrasive and determines how well the abrasive will cover the work area. The blast wheel motor circuit is equipped with a current ammeter on the equipment to give a visual indication of the abrasive flow to the wheel.

There is a magnet type abrasive control valve located between the abrasive storage hopper and the wheel feed spout to regulate the flow of abrasive from the storage hopper into the blast wheel. The volume of abrasive flow may be varied by the amount the abrasive valve is opened. The valve is manually actuated and is equipped with a mechanical variable stop arrangement that may be set to provide the desired shot flow rate. Valve stop adjustments are provided on the abrasive throttle lever located on the side of the operator's control panel.

The abrasive impacts the work surface, rebounding upward into a specially designed rebound chamber from where it is directed into an airwash dust extractor. Immediately following the rebound chamber is a compact chamber which separates the dust, pulverized abrasive, debris and other contaminants from the returning abrasive prior to its entry into the storage hopper. The returned abrasive is carried by momentum into the storage hopper, while lighter contaminants are conveyed up and away by a rapidly moving airstream. The airstream is generated by vacuum pressure from the dust collector. Dust is then conveyed and deposited in the dust filter chamber or baghouse.

The chassis is a three wheel, self-propelled unit with a drive system powered by a 1/4 HP, DC electric motor turning a drive wheel via chain drive and gear reducer. The travel speed is regulated by controlling the drive motor power through an electrical variable DC voltage regulator control located on the operator's control panel. A quick release pin on the drive wheel allows free wheeling for towing to and from the work site. The shot blast is designed to fit through a 34 inch door opening.

The Blastrac® operator's control panel is powered by a standard 110 volt line and has the following controls: speed control switch, travel switch, wheel start/stop buttons, hour meter, ammeter, on/off switch, and throttle for abrasive control valve.

The dust collector's control panel is located on the front of the chassis and has the following controls: blower running time, compressor start/stop buttons, and blower start/stop buttons.

SECTION 3 - HEALTH AND SAFETY EVALUATION

GENERAL SAFETY AND HEALTH CONCERNS

Personnel where the Blastrac® shot blast technology is being used need to be concerned with safety and health issues. Issues that personnel need to be cognizant of may be divided into two categories. Core issues are those that are based on current safety and health regulatory requirements. Best management practices are related to issues that are not based on current safety and health regulations, but are key elements in preventing worker injury and illness on the job.

Safety and health issues of concern with the Blastrac® shot blaster technology included:

Core Issues:

- ◆ Tripping hazards - The electric cords and vacuum hoses needed to operate the equipment are tripping hazards. Stringent housekeeping must be evaluated addressed.
- ◆ Pinch points - The potential exists for the operator to have his/her fingers/hand crushed if during operation the hand is placed in the area of the shot head or near any moving parts of the equipment. Blasting mode should never be activated while maintenance is being conducted on the head. This needs to be considered under a lockout/tagout program.

- ◆ Electrical hazards - The electrical panel and electric cords necessary to operate the equipment can present electrical hazards, therefore, the need for ground fault circuit interrupters, grounding, and strain relief must be addressed.
- ◆ While the electrical panel door was fitted with an interlock that does not allow operation of the Blastrac® with the door open, consideration must be given to working inside the panel when the power source is connected. This must be addressed under a lockout/tagout program.
- ◆ Lockout/Tagout - The user of the technology will need to develop a lockout/tagout program to assure there is not an accidental release of energy during maintenance/repair activities.
- ◆ Noise - The user was subjected to a significant amount of noise while operating the centrifugal shot blast.
- ◆ Dust - The equipment did not generate visible dust during operation, but larger debris and shot were left on the surface being blasted. The amount of dust generated in the breathing zone of the operator may change based on the environment in which the concrete decontamination is taking place; therefore, the user of the technology will need to develop a sampling plan based on the individual site needs. It should also be noted that there was potential for exposure to contamination when emptying the disposable bin on the dust collector.
- ◆ A large amount of shot was left on the surface during blasting operations. This has the potential to become an airborne hazard, especially after the shot is pulverized to a dust. Additionally, the shot left on the surface caused the surface to become very slippery.

Best Management Practices:

- ◆ Heat stress - The operator was subjected to an increase in heat stress due to the need to utilize Anti-C personal protective equipment (PPE). The user will need to develop a heat stress program for the environment in which the technology is being used, taking into consideration any PPE that may need to be utilized, ambient temperature, etc.
- ◆ Ergonomics - The user was subjected to some ergonomic stressors that need to be taken into consideration, such as, stooping, bending, twisting, kneeling, and lifting. Of particular concern is the need to manually empty dust and debris from

the disposable bin on the dust collector. This adds an ergonomic stressor to the back, and causes an increase in exposure to the contaminant.

- ◆ **Communication** - Due to the noise generated by the technology during operation, communication can be difficult. Personnel working in the area should be familiar with and use hand signals when needed.
- ◆ **Struck by Hazards** - There is potential for the operator and ancillary personnel in the area to be struck by shot coming from underneath the blast head. Any persons in the area where blasting is taking place must at a minimum wear safety glasses with side shields or goggles and a face shield. Additionally, long sleeves and long pants are recommended to keep shot from striking the skin.

INDUSTRIAL HYGIENE MONITORING

During this testing demonstration with the Blastrac® cleaning system, sampling was conducted for dust and noise. In addition, the wet-bulb globe temperature was monitored to evaluate heat stress. Observational evaluation was conducted for ergonomics.

Through general observational techniques the potential for ergonomic problems was evaluated during the testing demonstration. There is potential for muscle/back stress and/or injuries due to bending, twisting, and lifting associated with setup, operation, maintenance, and decontamination. Of particular concern is the potential for back injury due to the need to manually remove and empty the disposal bin on the dust collector.

Heat stress parameters were monitored using a Quest QuestTemp®15 Heat Stress Monitor. The wet-bulb globe temperature was used to determine the work/rest regimen in accordance with the American Conference of Governmental Industrial Hygienists (ACGIH) recommendations. The wet-bulb globe temperature was adjusted for the type of clothing, including PPE, that the worker was wearing in accordance with ACGIH guidelines. While heat stress will be increased when wearing PPE, the overall heat stress response will vary from worker to worker. Each situation in which the current technology is used will need to be evaluated for the heat stress potential, taking into consideration the wet-bulb globe temperature, PPE in use, physical condition of the worker, and amount of worker acclimatization.

Dust monitoring was conducted with a sampling train consisting of an SKC IOM Inhalable dust sampler coupled with a MSA Escort Elf air sampling pump. Pre- and post-sampling calibration was accomplished using a BIOS International DryCal DC1 primary calibration system. Sampling filters were desiccated pre- and post-sampling

and weighed on a Denver Instrument Company A-200DS scale. Sampling was conducted in accordance with NIOSH method 0500.

Personal dust sampling was conducted on the equipment operator during blasting operations. A personal dust sampling value of 0.0 mg/m^3 was obtained for the operator. This value does not exceed the Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) or the ACGIH threshold limit value (TLV) of 15 mg/m^3 and 10 mg/m^3 respectively for total dust. There was, however, a notable amount of shot left on the blasted surface. This could potentially become an airborne inhalation hazard, especially after the shot is pulverized and becomes a secondary source of dust. Due to this and the dust sampling being conducted in an outdoor environment with windy conditions, it is recommended that sampling be conducted while the shot blasting operation is being conducted in a closed environment. A complete air sampling plan for a site would need to be developed to include not only dust but other contaminants specific to the concrete decontamination project. (See Appendix B for sampling data).

Personal noise monitoring was conducted using Metrosonic db-3100 data logging noise dosimeters. Calibration was conducted pre- and post-monitoring using a Metrosonics CL304 acoustical calibrator. Monitoring was conducted on the operator for 4.3 hours (260 minutes) and 3.9 hours (236 minutes) during operation of the shot blast system. Monitoring during this time showed a noise dose of 29.73% and 23.78%, which gives an 8-hour time-weighted average (TWA) of 81.2 dBA and 79.6 dBA, respectively. If the operator continued to have the same level of noise exposure during the 8-hour shift, a projected 8-hour TWA would produce a noise dose of 52.97% and 84.2%, or an 8-hour TWA of 85.4 dBA and 88.76 dBA.

The OSHA allowable PEL for noise is a 100% dose or an 8-hour TWA of 90 dBA. The projected 8-hour TWA's are above the OSHA "active level" of 85 dBA. This would require the operator to be included in a hearing conservation program. There is also the possibility that these levels could increase if the shot blasting were to take place under different environmental conditions, in particular, an enclosed work environment. Feasible engineering controls, administrative controls, and personal protective equipment (PPE-hearing protection devices) need to be used as appropriate.

During the periods of operation, the noise levels were averaged for each one-minute period of time. An overall average was calculated, yielding an average exposure level of 85.4 dBA and 84.2 dBA. The maximum sound levels observed during the measurement periods were 106.25 dB during both periods. The highest instantaneous sound pressure level was 106.25 dB for both measurement periods.

These measurements define noise as a potential exposure problem for personnel operating the Blastrac® shot blasting system. It must also be noted that the equipment

was being operated in an open outdoor environment at the time of the measurements. Operation in an enclosed facility would have the potential to increase the noise level due to other influences such as vibration and reverberation. Therefore, it is recommended that noise monitoring be conducted while the equipment is being operated in a closed environment.

HUMAN FACTORS INTERFACE

The technologies being tested for concrete decontamination and decommissioning are targeted for alpha contaminated concrete. Therefore, the equipment operator was dressed out in Anti-C (alpha radiation) PPE which included cloth suit, hood, inner and outer boots, inner and outer gloves, and full face air-purifying respirator. Due to the full face respirator, the operator had some visibility problems while operating the equipment. There was also a decrease in dexterity and tactile sensation due to the gloves, which caused some problems during maintenance activities. In addition, the need to perform work in the Anti-C PPE caused an increase in heat stress for the operator.

If the concrete being decontaminated had contamination other than or in addition to alpha radiation, additional levels of protection, such as Level A or Level B PPE, may be required for the operator. These may create additional human interface problems such as a greater decrease in visibility and manual dexterity, an increase in heat stress, and an overall increase in physical stress.

The main ergonomic concern was removing and dumping the dust collected in the dust bin. This greatly increased the potential for exposure to the dust and associated contaminants and presented a potential for back injury.

TECHNOLOGY APPLICABILITY

On observation the technology did not deposit any visible dust into the atmosphere and air monitoring did not show a significant dust level, but this was difficult to assess due to the windy outdoor testing environment. There was a large amount of shot left on the surface during the blasting operation. The system needs to be evaluated to determine if an increase in capture velocity across the collection slot on the vacuum collection device would help this problem.

The Blastrac[®] shot blast will need to be disassembled to be decontaminated. This will not necessarily guarantee that decontamination for alpha radiation will be complete and it will be difficult to survey for alpha contamination due to all of the small hard to reach (with a probe) spaces inherent in the equipment. There is also concern for the amount

of contamination that may have been spread to the internal parts of the equipment when shot that has been on the surface is deposited back into the shot blaster for use.

SECTION 4 - JOB SAFETY ANALYSIS

JOB SAFETY ANALYSIS WHEELABRATOR BLASTRAC® SHOT BLAST CLEANING SYSTEM

HAZARD	CORRECTIVE ACTION
UNLOADING EQUIPMENT/SETUP	
* Pinch Points	<ul style="list-style-type: none"> * Use of hand protection * Use of proper hand tools for the job
* Slips/Trips/Falls	<ul style="list-style-type: none"> * Awareness of the specific hazards * Organization of materials (housekeeping) * Walking around areas that are congested/slippery when possible * Walking around tripping hazards when possible * Marking, isolating, bunching together tripping hazards such as electric cords
* Struck by/Caught between	<ul style="list-style-type: none"> * Awareness of where equipment is being moved to at all times * Prohibit worker from being between moving and stationary objects at all times * Keep personnel clear of moving objects * Use of proper warning devices on equipment
* Muscular/Back Injury	<ul style="list-style-type: none"> * Ergonomic training including safe lifting techniques * Use of equipment such as forklift or crane for unloading
* Electrical Hazards	<ul style="list-style-type: none"> * Assure worker properly trained in electrical safety * Assure all equipment properly grounded and use of ground fault circuit breakers

ADJUSTING CONTROL CAGE	
* Burn Hazard	<ul style="list-style-type: none"> * Wear gloves appropriate for use with hot surfaces * Worker awareness of potential burn hazards
BLASTING CONCRETE	
* Slips/Trips/Falls	<ul style="list-style-type: none"> * Awareness of site specific hazards * Job site organization of materials (housekeeping) * Walk around hazards when possible * Clean up shot left on concrete * Marking isolating, bunching together tripping hazards such as electrical cords
* Restricted Communication (associated with noise generated)	* Hand signals as standard operating procedures (SOP's)
* Noise	<ul style="list-style-type: none"> * Use engineering controls * Use administrative controls * Provide proper PPE devices and training
* Struck by/Caught between	<ul style="list-style-type: none"> * Prohibit workers from being in front of the operating shot blaster * Prohibit workers from being between operating machinery and stationary object
* Exposure to Contaminant and Shot	<ul style="list-style-type: none"> * Utilization of proper PPE, including respiratory protection * Better utilization of vacuum system * Use of HEPA filters with vacuum system * Assure seal around shot head in good condition
* Pinch Points	<ul style="list-style-type: none"> * Use of hand protection * Technology specific training
* Muscular/Back Injury	<ul style="list-style-type: none"> * Limit duration of work * Training on proper lifting techniques
* Spread of Contamination	<ul style="list-style-type: none"> * Better utilization of vacuum system * Assure seal around shot head in good condition

DUMPING DUST COLLECTOR	
* Exposure to Contaminants	<ul style="list-style-type: none"> * Use HEPA filters with dust collection system * Use of proper PPE, including respiratory protection
* Muscular/Back Injury	* Use mechanical means for removal and emptying of dust bin
* Slips/Trips/Falls	<ul style="list-style-type: none"> * Awareness of the specific hazards * Organization of materials (housekeeping) * Walking around areas that are congested/slippery when possible * Walking around tripping hazards when possible * Marking, isolating, bunching together tripping hazards such as electrical cords
* Pinch Points	<ul style="list-style-type: none"> * Use hand protection * Use of hand tools appropriate for the job
GENERAL MAINTENANCE	
* Exposure to contaminant	<ul style="list-style-type: none"> * Wear proper PPE and respiratory protection - may need additional gloves over anti-C gloves to avoid tears and rips to gloves * Have something to sit or kneel on so do not have additional personnel exposure from sitting or kneeling on contaminated surface
* Accidental activation of moving parts	* Use proper lockout/tagout procedures
* Pinch Points	<ul style="list-style-type: none"> * Use of hand protection * Use of hand tools appropriate for the job

<p>* Slips/Trips/Falls</p>	<ul style="list-style-type: none"> * Awareness of the specific hazards * Organization of materials (housekeeping) * Walking around areas that are congested/slippery when possible * Walking around tripping hazards when possible * Marking, isolating tripping hazards
<p>* Ergonomics (Bending/Kneeling/Lifting)</p>	<ul style="list-style-type: none"> * Limit duration of work * Use proper lifting techniques * Perform maintenance on elevated work platform * Ergonomic training to include proper lifting techniques

SECTION 5 - FAILURE MODE AND EFFECTS ANALYSIS

FAILURE MODE AND EFFECTS ANALYSIS WHEELABRATOR BLASTRAC® SHOT BLAST CLEANING SYSTEM

FAILURE MODE	EFFECT
* Lose vacuum pressure	*Potential for higher concentration of contaminant to be released into atmosphere *Potential for greater amount of shot to be left on surface
* Vacuum line is punctured/ruptured	*Potential for higher concentration of contaminant to be released into atmosphere * Potential for greater amount of shot to be left on the surface * Reduced capture efficiency
* Improper grounding of electrical components	*Potential electrocution hazard for workers
* Lose power	*Equipment shuts down with potential to momentarily release higher concentration of contaminant into atmosphere
* Abrasive seals worn, torn, etc.	*Potential for greater amounts of shot to be propelled from under the shot head and therefore strike the worker *Potential for increased exposure to contaminant
* Quick release pin on drive wheel fails to release	*Potential for worker muscular injury/strain/sprain when trying to move equipment without "free wheeling" ability
* Pulse pressure system fails to clean filters	*Potential for exposure to contaminants (if clogged filters cause a decrease in vacuum efficiency)

SECTION 6 - TECHNOLOGY SAFETY DATA SHEET

TECHNOLOGY SAFETY DATA SHEET WHEELABRATOR Blastrac® Shot Blast Cleaning System

SECTION 1: TECHNOLOGY IDENTITY

Manufacturer's Name and Address: The Wheelabrator Corporation Blastrac® Division 108 Pine Road Newnan, GA 30263	Emergency Contact: (770)251-6778
	Information Contact: (770)251-6778
	Date Prepared:
Other Names: Blastrac®	Signature of Preparer: Operating Engineers National Hazmat Program 1293 Airport Road, Beaver, WV 25813, phone 304-253-8674, fax 304-253-7758 Under cooperative agreement DE-FC21- 95 MC 32260

SECTION 2: PROCESS DESCRIPTION

The Wheelabrator Blastrac® Model 1-15D coupled with Model 654-DC dust collection system was used during the testing demonstration. The Blastrac® is a surface preparation downblast machine for closed-cycle abrasive cleaning of horizontal surfaces. Surface and contaminant removal are accomplished by the impact of metallic abrasive thrown by controlled centrifugal force from a power driven bladed wheel. The thrown abrasive impacts the surface and rebounds upwardly into a rebound chamber, which then directs the abrasive into an airwash dust extractor. The dust extractor removes dust, scale, and other contaminants from the abrasive. The shot is then delivered by gravity to the storage hopper for reuse by the blast wheel. The Blastrac® is self-propelled by a variable speed electric drive system. The rate of speed the Blastrac® is traveling determines the depth of surface material removed.

SECTION 3: PROCESS DIAGRAM

Model 1-15D

SECTION 3: PROCESS DIAGRAM

SEPARATOR 1-15D AIRFLOW

SECTION 3: PROCESS DIAGRAM

SEPARATOR 1-15D AIRFLOW

SECTION 4: CONTAMINANTS AND MEDIA

The technology has the potential to cause concrete dust and associated contaminants to become airborne. Specific contaminants need to be evaluated on a site-by-site, job-by-job basis to determine the potential for exposure.

SECTION 5: ASSOCIATED SAFETY HAZARDS

Probability of Occurrence of Hazard:

- 1 Hazard may be present but not expected over background level
- 2 Some level of hazard above background level known to be present
- 3 High hazard potential
- 4 Potential for imminent danger to life and health

A. ELECTRICAL (LOCKOUT/TAGOUT)

RISK RATING: 2

The shot blaster and associated equipment has the potential for electrical hazards. Assure proper grounding, use of ground fault circuit interrupters, and stress relievers on all equipment. Compliance with applicable electrical standards and codes and lockout/tagout procedures must be followed to assure the safety of personnel.

B. FIRE AND EXPLOSION

RISK RATING: 1

Technology does not pose this hazard in and of itself but could not be used in an explosive environment due to the potential for sparking.

C. CONFINED SPACE ENTRY

RISK RATING: 1

Not part of this technology unless the specific location where shot blast is being used is a confined space. In this case, confined space procedures would need to be followed.

D. MECHANICAL HAZARD

RISK RATING: 3

Use of large equipment and hand tools may pose the following: pinch points, struck by, caught between, and fall from above hazards.

E. PRESSURE HAZARDS

RISK RATING: N/A

Not part of this technology.

F. TRIPPING AND FALLING

RISK RATING: 3

Electrical cords and vacuum hoses present potential tripping hazards.

G. LADDERS AND PLATFORMS

RISK RATING: N/A

Not part of this technology.

H. MOVING VEHICLES	RISK RATING: 3
The presence of multiple pieces of mobile equipment (used to unload and load the technology) in relationship to a small area of operation may pose a significant danger. Sufficient warning devices such as horn, bells, lights, and back up alarms should be utilized. Personnel should be trained to work with and around moving equipment.	
I. BURIED UTILITIES, DRUMS AND TANKS	RISK RATING: N/A
Not part of this technology.	
J. PROTRUDING OBJECTS	RISK RATING: N/A
Not part of this technology.	
K. GAS CYLINDERS	RISK RATING: N/A
Not part of this technology.	
L. TRENCHING AND EXCAVATIONS	RISK RATING: N/A
Not part of this technology.	
M. OVERHEAD LIFTS	RISK RATING: 3
Unloading and loading of technology may require overhead lifts or the use of a forklift. Proper precautions indicated.	
N. OVERHEAD HAZARDS	RISK RATING: 2
Would only be present if a crane were required to unload or load equipment.	

SECTION 6: ASSOCIATED HEALTH HAZARDS	
A. INHALATION HAZARD	RISK RATING: 3
The shot blast produces dust from the concrete and associated contamination. Specific hazards will be identified from the site characterization. Evaluation of total dust and/or respirable dust generated needs to be conducted. The shot may also present an inhalation hazard, especially as it becomes pulverized.	
B. SKIN ABSORPTION	RISK RATING: 1
This would be dependent on the contaminants at the site and would be identified by the site characterization.	
C. HEAT STRESS	RISK RATING: 4
Ambient conditions correlated with work rates, PPE, etc. must be considered.	
D. NOISE	RISK RATING: 3
The technology presents the potential for a noise hazard.	

E. NON-IONIZING RADIATION	RISK RATING: N/A
Not part of this technology.	
F. IONIZING RADIATION	RISK RATING: 1-4
None associated with this technology, but the contaminated concrete may present a significant radiation exposure. This will be identified by the site characterization.	
G. COLD STRESS	RISK RATING: 1
Technology does not produce a hazard, but ambient conditions need to be considered.	
H. ERGONOMIC HAZARDS	RISK RATING: 3
Poses ergonomic hazards associated with lifting, bending, twisting, stooping, and/or kneeling. These may cause injury/strain to the back, knees, hips, and/or legs.	
I. OTHER	RISK RATING: N/A
None noted.	

SECTION 7: PHASE ANALYSIS

A. CONSTRUCTION/START-UP

The set-up/start-up phase presents several hazards including pinch points, slips/trips/falls, struck by/caught between, muscular/back injury, and electrical hazards.

B. OPERATION

The operational phase presents several hazards including exposure to contaminant (airborne and from the surface), muscular/back injury, mechanical hazards, electrical hazards, and exposure to noise.

C. MAINTENANCE

The maintenance phase presents several hazards including pinch points, slips/trips/falls, struck by/caught between, muscular/back injury, electrical hazards, exposure to contaminants (airborne and from the surface), and accidental activation of moving parts.

D. DECOMMISSIONING

The decommissioning phase presents several hazards including exposure to the contaminant, pinch points, slips/trips/falls and muscular/back injury.

SECTION 8: HEALTH AND SAFETY PLAN REQUIRED ELEMENTS

A. AIR MONITORING

When concrete is blasted, total and respirable dust need to be monitored. Monitoring also needs to be done for specific concrete contaminants and may need to be conducted for specific constituents of the concrete such as silica. In addition, noise monitoring is essential.

B. WORKER TRAINING

Training that would apply in this case may include but not be limited to: HAZWOPER (Hazardous Waste Operations and Emergency Response), HAZCOM (Hazard Communication), Respiratory Protection, Hearing Conservation, Ergonomics (proper lifting, bending, stooping, kneeling), specific training for equipment operation, CPR/First Aid/Emergency Response/Bloodborne Pathogens, Electrical Safety, Lockout/Tagout, Radiation Safety, Hand Signal Communication, Construction Safety (OSHA 500), and or General Industry Safety (OSHA 501)

C. EMERGENCY RESPONSE

Emergency response planning for a site needs to assure adequate coverage for hazards described in the TSDS. Having at least one person per shift trained in CPR and first aid is recommended.

D. MEDICAL SURVEILLANCE

Evaluation of personnel's general health with emphasis on the cardiovascular and respiratory system, back, and peripheral nervous system. Medical surveillance as specified by the OSHA standards needs to be conducted. Initial and annual audiograms.

E. INFORMATIONAL PROGRAM

Workers must be trained in specific operation of equipment before use.

SECTION 9: COMMENTS AND SPECIAL CONSIDERATIONS

Due to the noise produced, communication may become difficult. Personnel working in the area should be familiar with and use hand signals as necessary.

Only personnel who have been adequately trained in the operation of this technology should be permitted to operate and/or work with the equipment.

SECTION 7 - EMERGENCY RESPONSE/PREPAREDNESS

The use of the Wheelabrator shot blast technology would not be applicable to use in an emergency response situation.

Emergency response/preparedness must be part of every hazardous waste site safety and health plan. In addition to credible site emergencies, site personnel must plan for credible emergencies in connection with the Blastrac®.

All precautions used when responding to an emergency situation at the site will apply. Before entering an area where the centrifugal shot blaster is being used, the equipment needs to be completely shut down (de-energized).

This technology does not appear to present any conditions that would lead to out of the ordinary emergencies.

SECTION 8 - REGULATORY/POLICY ISSUES

The site safety and health personnel where the Blastrac® shot blast technology is being used need to be concerned with safety and health regulations applicable to the issues discussed above. Regulations that apply may be divided into four categories. Core requirements are those regulations that would apply to any hazardous waste work site, regardless of the type of job. Technology specific requirements are those regulations that apply due to the specific technology being used. Special requirements are standards and policies that are specific to the technology itself and are required by reference in a regulation. Best management practices are not required, but are recommended by organizations such as the American National Standards Institute (ANSI), the National Institute of Occupational Health and Safety (NIOSH), Department of Energy (DOE), National Fire Protection Association (NFPA), etc. These regulations/standards may include but not be limited to the following:

Core Requirements:

- ◆ OSHA 29 CFR 1926.25 Housekeeping
- ◆ OSHA 29 CFR 1910.141 Sanitation (1910.141(a)(3) covers housekeeping)
- ◆ OSHA 29 CFR 1926.53 Ionizing Radiation
- ◆ OSHA 29 CFR 1910.96 Ionizing Radiation
- ◆ OSHA 29 CFR 1926 Subpart Z Toxic and Hazardous Substances

- ◆ OSHA 29 CFR 1910 Subpart Z Toxic and Hazardous Substances
- ◆ OSHA 29 CFR 1926.59 Hazard Communication
- ◆ OSHA 29 CFR 1910.1200 Hazard Communication
- ◆ OSHA 29 CFR 1926.64 Process Safety Management of Highly Hazardous Chemicals
- ◆ OSHA 29 CFR 1910.119 Process Safety Management of Highly Hazardous Chemicals
- ◆ OSHA 29 CFR 1926.65 Hazardous Waste Operations and Emergency Response
- ◆ OSHA 29 CFR 1910.120 Hazardous Waste Operations and Emergency Response
- ◆ Occupational Safety and Health Act 1970(5)(a)(1) General Duty Clause

Technology Specific Requirements:

- ◆ OSHA 29 CFR 1926 Subpart K Electrical
- ◆ OSHA 29 CFR 1910 Subpart S Electrical
- ◆ OSHA 29 CFR 1910 Subpart O Machinery and Machine Guarding
- ◆ OSHA 29 CFR 1910.147 The Control of Hazardous Energy (Lockout/Tagout)
- ◆ OSHA 29 CFR 1926.52 Occupational Noise Exposure
- ◆ OSHA 29 CFR 1910.95 Occupational Noise Exposure
- ◆ OSHA 29 CFR 1926.103 Respiratory Protection
- ◆ OSHA 29 CFR 1910.134 Respiratory Protection
- ◆ OSHA 29 CFR 1926.102 Eye and Face Protection
- ◆ OSHA 29 CFR 1910.133 Eye and Face Protection

- ◆ OSHA 29 CFR 1926.28 Personal Protective Equipment
- ◆ OSHA 29 CFR 1910.132 General Requirements (Personal Protective Equipment)
- ◆ OSHA 29 CFR 1926.23 First Aid and Medical Attention
- ◆ OSHA 29 CFR 1910.151 Medical Services and First Aid

Best Management Practices:

- ◆ ACGIH Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices
- ◆ ANSI S3.34, Guide for the Measurement and Evaluation of Human Exposure to Vibration Transmitted to the Hand, New York, NY: American National Standards Institute

In addition to the above regulations and policies, it is imperative that all workers have appropriate and adequate training for the task and associated safety and health conditions. Training that would be required may be divided into four categories. Core training is that which is required for anyone entering a hazardous waste site to perform work, regardless of the type of job. Technology specific training is that training that is specific to the technology and required by safety and health standards. Special training is that which is specific to the technology to assure the worker is adequately trained for the task, but is not necessarily required by safety and health standards. Best management practices are trainings that while not mandated by health and safety standards, provide information and knowledge to the worker that will allow the worker to perform his/her job safely. Training to be applied for the centrifugal shot blast technology may include but not be limited to:

Core Training Requirements:

- ◆ HAZWOPER
- ◆ HAZCOM
- ◆ Radiation Safety (Radiation Worker Training) for radiation sites

Technology Specific Training:

- ◆ Respiratory Protection
- ◆ Hearing Conservation
- ◆ Personal Protective Equipment
- ◆ Electrical Safety
- ◆ Lockout/Tagout

Special Training:

- ◆ Job specific training for equipment operation

Best Management Practice Training:

- ◆ Ergonomics (proper lifting, bending, stooping, kneeling, safe shoveling techniques, arm-hand vibration)
- ◆ Heat stress (learning to recognize signs and symptoms)
- ◆ CPR/First Aid/Emergency Response/Blood-borne Pathogens
- ◆ Hand Signal Communication
- ◆ Construction Safety (OSHA 500) and or General Industry Safety (OSHA 501)

SECTION 9 - OPERATIONAL CONSIDERATIONS AND RECOMMENDATIONS

Recommendations made here for improved worker safety and health take into consideration the operation of the Blastrac[®] shot blast model 1-15D with dust collection system model 854-DC. Specific recommendations include:

- ◆ Workers must be aware of the tripping hazards associated with hoses and cords that are necessary to operate the equipment. Keeping these as orderly as possible in compliance with good housekeeping practices will help avoid injury due to tripping.

- ◆ Operators need to have training in ergonomics to assure proper techniques in lifting, bending, stooping, twisting, etc. during equipment operation and dust dumping activities.
- ◆ The use of the dust pan made it necessary for the workers to manually empty the accumulated dust by dumping the dust bin. This has the potential to cause ergonomic problems such as back stress/injury and greatly increases the potential for exposure to the contaminant. An automated system or a bagging system to contain the dust would reduce these hazards.

Figure 1. Worker pulling out dust bin from vacuum system.

- ◆ During blasting operations, there was a significant amount of shot left on the surface. This was collected using a large magnet and placed back into the blaster for reuse. Shot that is not left on the surface is recycled back into the equipment for reuse. Both of these practices have the potential to spread contamination to the internal parts of the equipment. The vacuum system needs to be evaluated to determine if an increase in capture velocity across the vacuum collection slot would alleviate this problem.

The shot left on the surface makes it very slippery. Further, it can create a secondary waste problem, because when it gets wet, it rusts. A design change to the vacuum system may also help with these problems.

- ◆ There is potential for overexposure to noise during operation of the technology. Since testing was done in an outdoor environment, it is plausible that the noise levels would increase in an enclosed environment. The equipment needs to be evaluated for possible engineering controls to help decrease the noise exposure to the operator. If engineering controls are not possible, administrative controls, and/or adequate hearing protection must be incorporated during operation.
- ◆ While the dust collection system contained filters, it did not use HEPA filters. This increases the potential for exposure to respirable size air-borne contaminant. It should be required that any dust collection system be used with HEPA filters.
- ◆ Prior to operation the operator must adjust the control cage. This requires that shot be directed onto a steel plate placed beneath the blast seals. This plate may become hot enough to cause a burn if touched. The operator must be

aware of this and use the appropriate gloves when handling the plate after adjusting the control cage.

- ◆ During maintenance and/or repair activities there is the potential for accidental activation of both mechanical and electrical energy. A proper lockout/tagout program will need to be developed for use with the shot blast.
- ◆ A forklift was used for unloading and setup of the shot blast. As stated in the operations manual, the electrical cords should not be run over with a forklift or other such equipment. Additionally, basic forklift safety needs to be observed when using this piece of equipment to assist in unloading, set up, loading, etc.
- ◆ The control panel on the shot blast and the vacuum unit had color coded push buttons with labeling but the button shapes were identical. Color blindness and/or the inability to read has the potential to cause operator error which could result in situations that may cause injury. Building redundancy into the recognition of the buttons by making them of different shapes in addition to color coding and labeling will decrease this potential.
- ◆ When moving the Blastrac®, the control is pushed backward to move the unit forward and vice versa. This could lead to operator error which could result in possible injury. Making the control compatible with the direction of movement will decrease this potential.

- ◆ The control panel on the Blastrac® is at a fixed height. Depending on the height of the operator, this requires the operator to bend constantly to see the controls. A control panel of adjustable height would help to alleviate this constant strain on the back.

Figure 2. Worker bending to adjust controls on control panel during blasting operations.

- ◆ Shot became a "struck by hazard" due to it becoming a projectile from underneath the Blastrac®. The shot was projected up to 25-30 feet during blasting. The shot was stinging to the skin and could cause severe injury to the eye. Long sleeves, long pants, safety glasses with sideshields or goggles and a face shield are essential during operation of the shot blast.
- ◆ The locking pin for the motor (of the Blastrac®) requires the operator to reach inside the guard to insert and remove it. This has the potential to cause injury to the fingers and/or hand if there was an accidental activation of the motor. A

method for inserting the pin without using the hand/fingers or locking out/tagging out energy sources while inserting or removing the pin would mitigate this hazard.

- ◆ The vacuum unit is on wheels that allow it to move freely and easily. Several times the operator had difficulty reinserting the dust bin because the unit moved. Putting some type of brakes on the wheels would correct this problem.
- ◆ The magnet used to pick shot up from the surface being blasted required the use of a manual slide mechanism to remove the shot from the magnet. This caused the hand to come into contact with the shot. This increases the potential for exposure to contaminants that may be attached to the shot. A mechanism to remove the shot without using the hand(s) needs to be developed.
- ◆ Due to the windy outdoor environment in which the testing demonstration was conducted and therefore, the dust and noise monitoring was conducted, it is recommended that further monitoring for dust and noise exposure be conducted while the technology is used in an enclosed environment similar to environments in which it would be used at a hazardous waste clean-up site. This would also allow for a more thorough evaluation of the heat stress that may be encountered while wearing the appropriate PPE.

The safety and health issues discussed throughout this report could be reduced and in some cases eliminated if this type of scabbling technology could operate remotely.

APPENDIX A REFERENCES

**Occupational Safety and Health Standards for General Industry, 29 CFR Part 1910,
Occupational Safety and Health Administration United States Department of Labor**

**Occupational Safety and Health Standards for the Construction Industry, 29 CFR Part
1926, Occupational Safety and Health Administration United States Department of
Labor**

**Threshold Limit Values(TLV's) for Chemical Substances and Physical Agents and
Biological Exposure Indices (BEI's), American Conference of Governmental Industrial
Hygienists, 1995-1996**

**ANSI S3.34, Guide for the Measurement and Evaluation of Human Exposure to
Vibration Transmitted to the Hand, New York, NY: American National Standards
Institute, ANSI 1986**

APPENDIX B IH SAMPLING DATA

WHEELABRATOR Blastac [®] Shot Blast Total Dust Sampling			
12/10/96	121096-FIU-001	Blank	0.0000 mg/m ³
12/10/96	121096-FIU-002	Total dust	0.0000 mg/m ³

* The OSHA PEL for total dust is 15 mg/m³ and the ACGIH TLV is 10 mg/m³. Current sampling was conducted for total dust. The need to sample for respirable dust and silica has to be considered during concrete decontamination and decommissioning activities.

APPENDIX C ACRONYMS

ACGIH	-	American Conference of Governmental Industrial Hygienists
ANSI	-	American National Standards Institute
CFR	-	Code of Federal Regulations
DC	-	direct current
DOE	-	Department of Energy
FIU	-	Florida International University
HAZCOM	-	Hazard Communication
HAZWOPER	-	Hazardous Waste Operations and Emergency Response
HP	-	horse power
NFPA	-	National Fire Protection Association
NIOSH	-	National Institute of Occupational Safety and Health
OSHA	-	Occupational Safety and Health Administration
PEL	-	permissible exposure limits
PPE	-	personal protective equipment
SOP's	-	standard operating procedures
TLV	-	threshold limit value
TWA	-	time-weighted average

WHEELABRATOR BLASTRAC®

TABLE OF CONTENTS

ACQUISITION & ASSISTANCE

1998 MAR 25 P 2: 32

USDOE-FETC

ACKNOWLEDGEMENTS.....	ii
EXECUTIVE SUMMARY	iii
SECTION 1 – SUMMARY	1
Technology Description	1
Key Results	1
SECTION 2 - SYSTEM OPERATION.....	2
SECTION 3 - HEALTH AND SAFETY EVALUATION	3
General Health and Safety Concerns.....	3
Core Issues	3
Best Management Practices.....	4
Industrial Hygiene Monitoring	5
Human Factors Interface	7
Technology Applicability	7
SECTION 4 - EMERGENCY RESPONSE/PREPAREDNESS.....	8
SECTION 5 - REGULATORY POLICY ISSUES	8
Core Requirements	8
Technology Specific Requirements	9
Best Management Practices.....	10
Core Training Requirements	10
Technology Specific Training	11
Special Training.....	11
Best Management Practice Training	11
SECTION 6 - OPERATIONAL CONSIDERATIONS AND RECOMMENDATIONS	11
APPENDIX A - REFERENCES	15
APPENDIX B - INDUSTRIAL HYGIENE DATA.....	16
APPENDIX C - ACRONYMS	17

ACKNOWLEDGEMENTS

The human factors assessment of Wheelabrator was conducted under support of the U.S. Department of Energy's Federal Energy Technology Center, under cooperative agreement DE-FC21-95MC32260 with the Operating Engineers National Hazmat Program. The Operating Engineers National Hazmat Program would like to thank the following people for their participation on the "research action team" and the professional expertise they provided for this assessment:

Barbara McCabe
David Mullins

Operating Engineers National Hazmat Program
Operating Engineers Local Union 132

EXECUTIVE SUMMARY

The Wheelabrator Blastrac® Model 1-15D coupled with Model 654-DC dust collection system was used during the testing demonstration. The Blastrac® is a surface preparation downblast machine for closed-cycle abrasive cleaning of horizontal surfaces. Surface and contaminant removal is accomplished by the impact of metallic abrasive thrown by controlled centrifugal force from a power driven bladed wheel. The thrown abrasive impacts the surface and rebounds upwardly into a rebound chamber, which then directs the abrasive into an airwash dust extractor. The dust extractor removes dust, scale, and other contaminants from the abrasive. The shot is then delivered by gravity to the storage hopper for reuse by the blast wheel. The Blastrac® is self-propelled by a variable speed electric drive system. The rate of speed the Blastrac® is traveling determines the depth of surface material removed.

During the assessment sampling was conducted for dust, and noise and general observational techniques were conducted for ergonomics. General observational techniques for ergonomics showed the potential for some ergonomic problems during surface coating removal using the Wheelabrator Blastrac®. There is potential for muscle/back stress and/or injuries due to bending, twisting, and lifting associated with setup, operation, maintenance, and decontamination. Of particular concern is the potential for back injury due to the need to manually remove and empty the disposal bin on the dust collector.

Personal air sampling was conducted on the equipment operator during blasting operations. A personal dust sampling value of 0.00 mg/m^3 was obtained for the operator. This value does not exceed the Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) and the American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV) of 15 mg/m^3 and 10 mg/m^3 respectively for total dust. There was, however, a notable amount of shot left on the blasted surface. This could potentially become an airborne inhalation hazard, especially after the shot is pulverized and becomes a secondary source of dust. Due to this and the dust sampling being conducted in an outdoor environment with windy conditions, it is recommended that sampling be conducted while the shot blasting operation is being conducted in a closed environment. A complete air sampling plan for a site would need to be developed to include not only dust but other contaminants specific to the concrete decontamination project.

Personal noise monitoring on the operator showed noise levels ranging from 23.78% which would give an 8-hour time weighted average (TWA) of 79.6 dBA to 29.73% (TWA – 81.2 dBA).

The OSHA allowable PEL for noise is a 100% dose or an 8-hour TWA of 90 dBA. While the operator was not overexposed during the sampling periods but the

8-hour projected exposure levels would be above the OSHA "action level" and of 85 dBA and would require the operator to be included in a hearing conservation program.

Recommendations for improved worker safety and health during use of the Wheelabrator Blastrac® include: 1. keeping all hoses and lines as orderly as possible in compliance with good housekeeping requirements; 2. ergonomic training to include techniques in lifting, bending, stooping, twisting, etc.; 3. an automated dust collection system or a bagging system to contain the dust; 4. evaluation of the capture velocity on the vacuum system to determine if the an increase in capture velocity would keep less shot off of the surface being blasted; 5. use of HEPA filters in the dust collection system; 6. an adjustable control panel; 7. brakes on the wheels of the vacuum system; and 8. the use of faceshields in addition to safety glasses with sideshields or goggles.

WHEELABRATOR Blastrac® Shot Blast Cleaning System Human Factors Evaluation

SECTION 1 - SUMMARY

TECHNOLOGY DESCRIPTION

The Blastrac® shot blast technology was tested and is being evaluated at Florida International University (FIU) as a baseline technology. In conjunction with FIU's evaluation of efficiency and cost, this report covers the hazard analysis and safety evaluation. The Blastrac® is a commercially available technology and has been used for various projects at locations throughout the country.

The Wheelabrator Blastrac® Model 1-15D coupled with Model 654-DC dust collection system was used during the testing demonstration. The Blastrac® is a surface preparation downblast machine for closed-cycle abrasive cleaning of horizontal surfaces. Surface and contaminant removal are accomplished by the impact of metallic abrasive thrown by controlled centrifugal force from a power driven bladed wheel. The thrown abrasive impacts the surface and rebounds upwardly into a rebound chamber, which then directs the abrasive into an airwash dust extractor. The dust extractor removes dust, scale, and other contaminants from the abrasive. The shot is then delivered by gravity to the storage hopper for reuse by the blast wheel. The Blastrac® is self-propelled by a variable speed electric drive system. The rate of speed the Blastrac® is traveling determines the depth of surface material removed.

KEY RESULTS

The safety and health evaluation during the testing demonstration focused on two main areas of exposure: dust and noise. Dust exposure was minimal but noise exposure was significant. Further testing for each of these exposures is recommended because of the outdoor environment where the testing demonstration took place may cause the results to be inapplicable to enclosed operating environments, where it is feasible that the dust and noise levels will be higher. Other safety and health issues found were ergonomics, heat stress, tripping hazards, electrical hazards, and lockout/tagout.

SECTION 2 - SYSTEM OPERATION

The Wheelabrator Blastrac® Model 1-15D coupled with Model 654-DC dust collection system was used during the testing demonstration. The Blastrac® is a surface preparation downblast machine for closed-cycle abrasive cleaning of horizontal surfaces. Surface and contaminant removal are accomplished by the impact of metallic abrasive thrown by controlled centrifugal force from a power driven bladed wheel. The thrown abrasive impacts the surface and rebounds upwardly into a rebound chamber, which then directs the abrasive into an airwash dust extractor. The dust extractor removes dust, scale, and other contaminants from the abrasive. The shot is then delivered by gravity to the storage hopper for reuse by the blast wheel. The Blastrac® is self-propelled by a variable speed electric drive system. The rate of speed the Blastrac® is traveling determines the depth of surface material removed.

The Wheelabrator unit consists of a power driven four bladed wheel that throws abrasive by centrifugal force toward the surface to be blasted. The unit is enclosed in a guard housing of abrasive-resistant material and lined where necessary with replaceable wear plates. The wheel is driven by a 3600 RPM electrical motor. An impeller feeds the abrasive (shot) in controlled amounts onto the blades of the rotating wheel. The abrasive fed into the center of the rotating impeller is given its initial circular motion to direct it through the control cage opening and onto the wheel blades. The control cage directs the abrasive and determines how well the abrasive will cover the work area. The blast wheel motor circuit is equipped with a current ammeter on the equipment to give a visual indication of the abrasive flow to the wheel.

There is a magnet type abrasive control valve located between the abrasive storage hopper and the wheel feed spout to regulate the flow of abrasive from the storage hopper into the blast wheel. The volume of abrasive flow may be varied by the amount the abrasive valve is opened. The valve is manually actuated and is equipped with a mechanical variable stop arrangement that may be set to provide the desired shot flow rate. Valve stop adjustments are provided on the abrasive throttle lever located on the side of the operator's control panel.

The abrasive impacts the work surface, rebounding upward into a specially designed rebound chamber from where it is directed into an airwash dust extractor. Immediately following the rebound chamber is a compact chamber which separates the dust, pulverized abrasive, debris and other contaminants from the returning abrasive prior to its entry into the storage hopper. The returned abrasive is carried by momentum into the storage hopper, while lighter contaminants are conveyed up and away by a rapidly moving airstream. The airstream is generated by vacuum pressure from the dust collector. Dust is then conveyed and deposited in the dust filter chamber or baghouse.

The chassis is a three wheel, self-propelled unit with a drive system powered by a 1/4 HP, DC electric motor turning a drive wheel via chain drive and gear reducer. The travel speed is regulated by controlling the drive motor power through an electrical variable DC voltage regulator control located on the operator's control panel. A quick release pin on the drive wheel allows free wheeling for towing to and from the work site. The shot blast is designed to fit through a 34 inch door opening.

The Blastrac® operator's control panel is powered by a standard 110 volt line and has the following controls: speed control switch, travel switch, wheel start/stop buttons, hour meter, ammeter, on/off switch, and throttle for abrasive control valve.

The dust collector's control panel is located on the front of the chassis and has the following controls: blower running time, compressor start/stop buttons, and blower start/stop buttons.

SECTION 3 - HEALTH AND SAFETY EVALUATION

GENERAL SAFETY AND HEALTH CONCERNS

Personnel where the Blastrac® shot blast technology is being used need to be concerned with safety and health issues. Issues that personnel need to be cognizant of may be divided into two categories. Core issues are those that are based on current safety and health regulatory requirements. Best management practices are related to issues that are not based on current safety and health regulations, but are key elements in preventing worker injury and illness on the job.

Safety and health issues of concern with the Blastrac® shot blaster technology included:

Core Issues:

- ◆ Tripping hazards - The electric cords and vacuum hoses needed to operate the equipment are tripping hazards. Stringent housekeeping must be evaluated addressed.
- ◆ Pinch points - The potential exists for the operator to have his/her fingers/hand crushed if during operation the hand is placed in the area of the shot head or near any moving parts of the equipment. Blasting mode should never be activated while maintenance is being conducted on the head. This needs to be considered under a lockout/tagout program.

- ◆ **Electrical hazards** - The electrical panel and electric cords necessary to operate the equipment can present electrical hazards, therefore, the need for ground fault circuit interrupters, grounding, and strain relief must be addressed.
- ◆ While the electrical panel door was fitted with an interlock that does not allow operation of the Blastrac® with the door open, consideration must be given to working inside the panel when the power source is connected. This must be addressed under a lockout/tagout program.
- ◆ **Lockout/Tagout** - The user of the technology will need to develop a lockout/tagout program to assure there is not an accidental release of energy during maintenance/repair activities.
- ◆ **Noise** - The user was subjected to a significant amount of noise while operating the centrifugal shot blast.
- ◆ **Dust** - The equipment did not generate visible dust during operation, but larger debris and shot were left on the surface being blasted. The amount of dust generated in the breathing zone of the operator may change based on the environment in which the concrete decontamination is taking place; therefore, the user of the technology will need to develop a sampling plan based on the individual site needs. It should also be noted that there was potential for exposure to contamination when emptying the disposable bin on the dust collector.
- ◆ A large amount of shot was left on the surface during blasting operations. This has the potential to become an airborne hazard, especially after the shot is pulverized to a dust. Additionally, the shot left on the surface caused the surface to become very slippery.

Best Management Practices:

- ◆ **Heat stress** - The operator was subjected to an increase in heat stress due to the need to utilize Anti-C personal protective equipment (PPE). The user will need to develop a heat stress program for the environment in which the technology is being used, taking into consideration any PPE that may need to be utilized, ambient temperature, etc.
- ◆ **Ergonomics** - The user was subjected to some ergonomic stressors that need to be taken into consideration, such as, stooping, bending, twisting, kneeling, and lifting. Of particular concern is the need to manually empty dust and debris from

the disposable bin on the dust collector. This adds an ergonomic stressor to the back, and causes an increase in exposure to the contaminant.

- ◆ **Communication** - Due to the noise generated by the technology during operation, communication can be difficult. Personnel working in the area should be familiar with and use hand signals when needed.
- ◆ **Struck by Hazards** - There is potential for the operator and ancillary personnel in the area to be struck by shot coming from underneath the blast head. Any persons in the area where blasting is taking place must at a minimum wear safety glasses with side shields or goggles and a face shield. Additionally, long sleeves and long pants are recommended to keep shot from striking the skin.

INDUSTRIAL HYGIENE MONITORING

During this testing demonstration with the Blastrac® cleaning system, sampling was conducted for dust and noise. In addition, the wet-bulb globe temperature was monitored to evaluate heat stress. Observational evaluation was conducted for ergonomics.

Through general observational techniques the potential for ergonomic problems was evaluated during the testing demonstration. There is potential for muscle/back stress and/or injuries due to bending, twisting, and lifting associated with setup, operation, maintenance, and decontamination. Of particular concern is the potential for back injury due to the need to manually remove and empty the disposal bin on the dust collector.

Heat stress parameters were monitored using a Quest QuestTemp®15 Heat Stress Monitor. The wet-bulb globe temperature was used to determine the work/rest regimen in accordance with the American Conference of Governmental Industrial Hygienists (ACGIH) recommendations. The wet-bulb globe temperature was adjusted for the type of clothing, including PPE, that the worker was wearing in accordance with ACGIH guidelines. While heat stress will be increased when wearing PPE, the overall heat stress response will vary from worker to worker. Each situation in which the current technology is used will need to be evaluated for the heat stress potential, taking into consideration the wet-bulb globe temperature, PPE in use, physical condition of the worker, and amount of worker acclimatization.

Dust monitoring was conducted with a sampling train consisting of an SKC IOM Inhalable dust sampler coupled with a MSA Escort Elf air sampling pump. Pre- and post-sampling calibration was accomplished using a BIOS International DryCal DC1 primary calibration system. Sampling filters were desiccated pre- and post-sampling

and weighed on a Denver Instrument Company A-200DS scale. Sampling was conducted in accordance with NIOSH method 0500.

Personal dust sampling was conducted on the equipment operator during blasting operations. A personal dust sampling value of 0.0 mg/m^3 was obtained for the operator. This value does not exceed the Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) or the ACGIH threshold limit value (TLV) of 15 mg/m^3 and 10 mg/m^3 respectively for total dust. There was, however, a notable amount of shot left on the blasted surface. This could potentially become an airborne inhalation hazard, especially after the shot is pulverized and becomes a secondary source of dust. Due to this and the dust sampling being conducted in an outdoor environment with windy conditions, it is recommended that sampling be conducted while the shot blasting operation is being conducted in a closed environment. A complete air sampling plan for a site would need to be developed to include not only dust but other contaminants specific to the concrete decontamination project. (See Appendix B for sampling data).

Personal noise monitoring was conducted using Metrosonic db-3100 data logging noise dosimeters. Calibration was conducted pre- and post-monitoring using a Metrosonics CL304 acoustical calibrator. Monitoring was conducted on the operator for 4.3 hours (260 minutes) and 3.9 hours (236 minutes) during operation of the shot blast system. Monitoring during this time showed a noise dose of 29.73% and 23.78%, which gives an 8-hour time-weighted average (TWA) of 81.2 dBA and 79.6 dBA, respectively. If the operator continued to have the same level of noise exposure during the 8-hour shift, a projected 8-hour TWA would produce a noise dose of 52.97% and 84.2%, or an 8-hour TWA of 85.4 dBA and 88.76 dBA.

The OSHA allowable PEL for noise is a 100% dose or an 8-hour TWA of 90 dBA. The projected 8-hour TWA's are above the OSHA "active level" of 85 dBA. This would require the operator to be included in a hearing conservation program. There is also the possibility that these levels could increase if the shot blasting were to take place under different environmental conditions, in particular, an enclosed work environment. Feasible engineering controls, administrative controls, and personal protective equipment (PPE-hearing protection devices) need to be used as appropriate.

During the periods of operation, the noise levels were averaged for each one-minute period of time. An overall average was calculated, yielding an average exposure level of 85.4 dBA and 84.2 dBA. The maximum sound levels observed during the measurement periods were 106.25 dB during both periods. The highest instantaneous sound pressure level was 106.25 dB for both measurement periods.

These measurements define noise as a potential exposure problem for personnel operating the Blastrac® shot blasting system. It must also be noted that the equipment was being operated in an open outdoor environment at the time of the measurements. Operation in an enclosed facility would have the potential to increase the noise level due to other influences such as vibration and reverberation. Therefore, it is recommended that noise monitoring be conducted while the equipment is being operated in a closed environment.

HUMAN FACTORS INTERFACE

The technologies being tested for concrete decontamination and decommissioning are targeted for alpha contaminated concrete. Therefore, the equipment operator was dressed out in Anti-C (alpha radiation) PPE which included cloth suit, hood, inner and outer boots, inner and outer gloves, and full face air-purifying respirator. Due to the full face respirator, the operator had some visibility problems while operating the equipment. There was also a decrease in dexterity and tactile sensation due to the gloves, which caused some problems during maintenance activities. In addition, the need to perform work in the Anti-C PPE caused an increase in heat stress for the operator.

If the concrete being decontaminated had contamination other than or in addition to alpha radiation, additional levels of protection, such as Level A or Level B PPE, may be required for the operator. These may create additional human interface problems such as a greater decrease in visibility and manual dexterity, an increase in heat stress, and an overall increase in physical stress.

The main ergonomic concern was removing and dumping the dust collected in the dust bin. This greatly increased the potential for exposure to the dust and associated contaminants and presented a potential for back injury.

TECHNOLOGY APPLICABILITY

On observation the technology did not deposit any visible dust into the atmosphere and air monitoring did not show a significant dust level, but this was difficult to assess due to the windy outdoor testing environment. There was a large amount of shot left on the surface during the blasting operation. The system needs to be evaluated to determine if an increase in capture velocity across the collection slot on the vacuum collection device would help this problem.

The Blastrac® shot blast will need to be disassembled to be decontaminated. This will not necessarily guarantee that decontamination for alpha radiation will be complete and it will be difficult to survey for alpha contamination due to all of the small hard to reach

(with a probe) spaces inherent in the equipment. There is also concern for the amount of contamination that may have been spread to the internal parts of the equipment when shot that has been on the surface is deposited back into the shot blaster for use.

SECTION 4 - EMERGENCY RESPONSE/PREPAREDNESS

The use of the Wheelabrator shot blast technology would not be applicable to use in an emergency response situation.

Emergency response/preparedness must be part of every hazardous waste site safety and health plan. In addition to credible site emergencies, site personnel must plan for credible emergencies in connection with the Blastrac®.

All precautions used when responding to an emergency situation at the site will apply. Before entering an area where the centrifugal shot blaster is being used, the equipment needs to be completely shut down (de-energized).

This technology does not appear to present any conditions that would lead to out of the ordinary emergencies.

SECTION 5 - REGULATORY/POLICY ISSUES

The site safety and health personnel where the Blastrac® shot blast technology is being used need to be concerned with safety and health regulations applicable to the issues discussed above. Regulations that apply may be divided into four categories. Core requirements are those regulations that would apply to any hazardous waste work site, regardless of the type of job. Technology specific requirements are those regulations that apply due to the specific technology being used. Special requirements are standards and policies that are specific to the technology itself and are required by reference in a regulation. Best management practices are not required, but are recommended by organizations such as the American National Standards Institute (ANSI), the National Institute of Occupational Health and Safety (NIOSH), Department of Energy (DOE), National Fire Protection Association (NFPA), etc. These regulations/standards may include but not be limited to the following:

Core Requirements:

- ◆ OSHA 29 CFR 1926.25 Housekeeping
- ◆ OSHA 29 CFR 1910.141 Sanitation (1910.141(a)(3) covers housekeeping)
- ◆ OSHA 29 CFR 1926.53 Ionizing Radiation

- ◆ OSHA 29 CFR 1910.96 Ionizing Radiation
- ◆ OSHA 29 CFR 1926 Subpart Z Toxic and Hazardous Substances
- ◆ OSHA 29 CFR 1910 Subpart Z Toxic and Hazardous Substances
- ◆ OSHA 29 CFR 1926.59 Hazard Communication
- ◆ OSHA 29 CFR 1910.1200 Hazard Communication
- ◆ OSHA 29 CFR 1926.64 Process Safety Management of Highly Hazardous Chemicals
- ◆ OSHA 29 CFR 1910.119 Process Safety Management of Highly Hazardous Chemicals
- ◆ OSHA 29 CFR 1926.65 Hazardous Waste Operations and Emergency Response
- ◆ OSHA 29 CFR 1910.120 Hazardous Waste Operations and Emergency Response
- ◆ Occupational Safety and Health Act 1970(5)(a)(1) General Duty Clause

Technology Specific Requirements:

- ◆ OSHA 29 CFR 1926 Subpart K Electrical
- ◆ OSHA 29 CFR 1910 Subpart S Electrical
- ◆ OSHA 29 CFR 1910 Subpart O Machinery and Machine Guarding
- ◆ OSHA 29 CFR 1910.147 The Control of Hazardous Energy (Lockout/Tagout)
- ◆ OSHA 29 CFR 1926.52 Occupational Noise Exposure
- ◆ OSHA 29 CFR 1910.95 Occupational Noise Exposure
- ◆ OSHA 29 CFR 1926.103 Respiratory Protection
- ◆ OSHA 29 CFR 1910.134 Respiratory Protection

- ◆ OSHA 29 CFR 1926.102 Eye and Face Protection
- ◆ OSHA 29 CFR 1910.133 Eye and Face Protection
- ◆ OSHA 29 CFR 1926.28 Personal Protective Equipment
- ◆ OSHA 29 CFR 1910.132 General Requirements (Personal Protective Equipment)
- ◆ OSHA 29 CFR 1926.23 First Aid and Medical Attention
- ◆ OSHA 29 CFR 1910.151 Medical Services and First Aid

Best Management Practices:

- ◆ ACGIH Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices
- ◆ ANSI S3.34, Guide for the Measurement and Evaluation of Human Exposure to Vibration Transmitted to the Hand, New York, NY: American National Standards Institute

In addition to the above regulations and policies, it is imperative that all workers have appropriate and adequate training for the task and associated safety and health conditions. Training that would be required may be divided into four categories. Core training is that which is required for anyone entering a hazardous waste site to perform work, regardless of the type of job. Technology specific training is that training that is specific to the technology and required by safety and health standards. Special training is that which is specific to the technology to assure the worker is adequately trained for the task, but is not necessarily required by safety and health standards. Best management practices are trainings that while not mandated by health and safety standards, provide information and knowledge to the worker that will allow the worker to perform his/her job safely. Training to be applied for the centrifugal shot blast technology may include but not be limited to:

Core Training Requirements:

- ◆ HAZWOPER
- ◆ HAZCOM

- ◆ Radiation Safety (Radiation Worker Training) for radiation sites

Technology Specific Training:

- ◆ Respiratory Protection
- ◆ Hearing Conservation
- ◆ Personal Protective Equipment
- ◆ Electrical Safety
- ◆ Lockout/Tagout

Special Training:

- ◆ Job specific training for equipment operation

Best Management Practice Training:

- ◆ Ergonomics (proper lifting, bending, stooping, kneeling, safe shoveling techniques, arm-hand vibration)
- ◆ Heat stress (learning to recognize signs and symptoms)
- ◆ CPR/First Aid/Emergency Response/Blood-borne Pathogens
- ◆ Hand Signal Communication
- ◆ Construction Safety (OSHA 500) and or General Industry Safety (OSHA 501)

SECTION 6 - OPERATIONAL CONSIDERATIONS AND RECOMMENDATIONS

Recommendations made here for improved worker safety and health take into consideration the operation of the Blastrac® shot blast model 1-15D with dust collection system model 854-DC. Specific recommendations include:

- ◆ Workers must be aware of the tripping hazards associated with hoses and cords that are necessary to operate the equipment. Keeping these as orderly as

possible in compliance with good housekeeping practices will help avoid injury due to tripping.

- ◆ Operators need to have training in ergonomics to assure proper techniques in lifting, bending, stooping, twisting, etc. during equipment operation and dust dumping activities.
- ◆ The use of the dust pan made it necessary for the workers to manually empty the accumulated dust by dumping the dust bin. This has the potential to cause ergonomic problems such as back stress/injury and greatly increases the potential for exposure to the contaminant. An automated system or a bagging system to contain the dust would reduce these hazards.

Figure 1. Worker pulling out dust bin from vacuum system.

- ◆ During blasting operations, there was a significant amount of shot left on the surface. This was collected using a large magnet and placed back into the blaster for reuse. Shot that is not left on the surface is recycled back into the equipment for reuse. Both of these practices have the potential to spread contamination to the internal parts of the equipment. The vacuum system needs to be evaluated to determine if an increase in capture velocity across the vacuum collection slot would alleviate this problem.

The shot left on the surface makes it very slippery. Further, it can create a secondary waste problem, because when it gets wet, it rusts. A design change to the vacuum system may also help with these problems.

- ◆ There is potential for overexposure to noise during operation of the technology. Since testing was done in an outdoor environment, it is plausible that the noise levels would increase in an enclosed environment. The equipment needs to be evaluated for possible engineering controls to help decrease the noise exposure to the operator. If engineering controls are not possible, administrative controls, and/or adequate hearing protection must be incorporated during operation.
- ◆ While the dust collection system contained filters, it did not use HEPA filters. This increases the potential for exposure to respirable size air-borne contaminant. It should be required that any dust collection system be used with HEPA filters.

- ◆ Prior to operation the operator must adjust the control cage. This requires that shot be directed onto a steel plate placed beneath the blast seals. This plate may become hot enough to cause a burn if touched. The operator must be aware of this and use the appropriate gloves when handling the plate after adjusting the control cage.
- ◆ During maintenance and/or repair activities there is the potential for accidental activation of both mechanical and electrical energy. A proper lockout/tagout program will need to be developed for use with the shot blast.
- ◆ A forklift was used for unloading and setup of the shot blast. As stated in the operations manual, the electrical cords should not be run over with a forklift or other such equipment. Additionally, basic forklift safety needs to be observed when using this piece of equipment to assist in unloading, set up, loading, etc.
- ◆ The control panel on the shot blast and the vacuum unit had color coded push buttons with labeling but the button shapes were identical. Color blindness and/or the inability to read has the potential to cause operator error which could result in situations that may cause injury. Building redundancy into the recognition of the buttons by making them of different shapes in addition to color coding and labeling will decrease this potential.
- ◆ When moving the Blastrac[®], the control is pushed backward to move the unit forward and vice versa. This could lead to operator error which could result in possible injury. Making the control compatible with the direction of movement will decrease this potential.

Figure 2. Worker bending to adjust controls on control panel during blasting operations.

- ◆ The control panel on the Blastrac[®] is at a fixed height. Depending on the height of the operator, this requires the operator to bend constantly to see the controls. A control panel of adjustable height would help to alleviate this constant strain on the back.

- ◆ Shot became a "struck by hazard" due to it becoming a projectile from underneath the Blastrac[®]. The shot was projected up to 25-30 feet during blasting. The shot was stinging to the skin and could cause severe injury to the eye. Long sleeves, long pants, safety glasses with sideshields or goggles and a face shield are essential during operation of the shot blast.

- ◆ The locking pin for the motor (of the Blastrac®) requires the operator to reach inside the guard to insert and remove it. This has the potential to cause injury to the fingers and/or hand if there was an accidental activation of the motor. A method for inserting the pin without using the hand/fingers or locking out/tagging out energy sources while inserting or removing the pin would mitigate this hazard.
- ◆ The vacuum unit is on wheels that allow it to move freely and easily. Several times the operator had difficulty reinserting the dust bin because the unit moved. Putting some type of brakes on the wheels would correct this problem.
- ◆ The magnet used to pick shot up from the surface being blasted required the use of a manual slide mechanism to remove the shot from the magnet. This caused the hand to come into contact with the shot. This increases the potential for exposure to contaminants that may be attached to the shot. A mechanism to remove the shot without using the hand(s) needs to be developed.
- ◆ Due to the windy outdoor environment in which the testing demonstration was conducted and therefore, the dust and noise monitoring was conducted, it is recommended that further monitoring for dust and noise exposure be conducted while the technology is used in an enclosed environment similar to environments in which it would be used at a hazardous waste clean-up site. This would also allow for a more thorough evaluation of the heat stress that may be encountered while wearing the appropriate PPE.

The safety and health issues discussed throughout this report could be reduced and in some cases eliminated if this type of scabbling technology could operate remotely.

APPENDIX A REFERENCES

**Occupational Safety and Health Standards for General Industry, 29 CFR Part 1910,
Occupational Safety and Health Administration United States Department of Labor**

**Occupational Safety and Health Standards for the Construction Industry, 29 CFR Part
1926, Occupational Safety and Health Administration United States Department of
Labor**

**Threshold Limit Values(TLV's) for Chemical Substances and Physical Agents and
Biological Exposure Indices (BEI's), American Conference of Governmental Industrial
Hygienists, 1995-1996**

**ANSI S3.34, Guide for the Measurement and Evaluation of Human Exposure to
Vibration Transmitted to the Hand, New York, NY: American National Standards
Institute, ANSI 1986**

APPENDIX B IH SAMPLING DATA

WHEELABRATOR Blastac Shot Blast Total Dust Sampling			
12/10/96	121096-FIU-001	Blank	0.0000 mg/m ³
12/10/96	121096-FIU-002	Total dust	0.0000 mg/m ³

* The OSHA PEL for total dust is 15 mg/m³ and the ACGIH TLV is 10 mg/m³. Current sampling was conducted for total dust. The need to sample for respirable dust and silica has to be considered during concrete decontamination and decommissioning activities.

APPENDIX C ACRONYMS

ACGIH	-	American Conference of Governmental Industrial Hygienists
ANSI	-	American National Standards Institute
CFR	-	Code of Federal Regulations
DC	-	direct current
DOE	-	Department of Energy
FIU	-	Florida International University
HAZCOM	-	Hazard Communication
HAZWOPER	-	Hazardous Waste Operations and Emergency Response
HP	-	horse power
NFPA	-	National Fire Protection Association
NIOSH	-	National Institute of Occupational Safety and Health
OSHA	-	Occupational Safety and Health Administration
PEL	-	permissible exposure limits
PPE	-	personal protective equipment
SOP's	-	standard operating procedures
TLV	-	threshold limit value
TWA	-	time-weighted average